ADVANCES
IN AMPHIBIAN RESEARCH
IN THE FORMER SOVIET UNION
VOL. 10 ♦ 2006

Sergei M. Drobenkov, Ruslan V. Novitsky, Lyudmila V. Kosova,
Konstantin K. Ryzhevich &
Mikhail M. Pikulik

THE AMPHIBIANS OF BELARUS

PENSOFT

IUCN (The World Conservation Union)
Species Survival Commission
Declining Amphibian Populations Task Force
Regional Group for the Commonwealth of
Independent States

Russian Academy of Sciences
A.N. Severtzov Institute of Ecology
and Evolution

THE AMPHIBIANS OF BELARUS

BY

SERGEI M. DROBENKOV, RUSLAN V. NOVITSKY, LYUDMILA V. KOSOVA,
KONSTANTIN K. RYZHEVICH & MIKHAIL M. PIKULIK

ADVANCES IN AMPHIBIAN RESEARCH
IN THE FORMER SOVIET UNION

Volume 10
2005

PENSOFT

Sofia - Moscow
2005

IUCN (The World Conservation Union)
Species Survival Commission
Declining Amphibian Populations Task Force
Regional Group for the Commonwealth of
Independent States

Russian Academy of Sciences
A.N. Severtzov Institute of Ecology
and Evolution

ADVANCES IN AMPHIBIAN RESEARCH IN THE FORMER SOVIET UNION

ISSN 1310-8840

All inquiries about subscription should be addressed to:

Pensoft Publishers
Dr. Lyubomir D. Penev, Pensoft Publishers, Geo Milev Str. 13a, Sofia 1113, Bulgaria
E-mail: pensoft@mbox.infotel.bg
Pensoft Online Bookshop: ***www.pensoft.net***

ISBN-10: 954-642-261-4 (Volume 10)
ISBN-13: 978-954-642-261-3 (Volume 10)

EDITORIAL

While presenting the anniversary tenth volume of the Advances in Amphibian Research in the former Soviet Union (AARFSU), it is not unreasonable to glance first at the preceding volumes published since 1996.

The AARFSU was intended as an annual issue specializing on amphibian researches in the republics of the former Soviet Union. Initially, it included scientific papers and brief communications on various aspects of batrachology, including systematics, distribution, ecology, behavior, conservation, morphology, evolution, paleontology, physiology, biochemistry, genetics and batrachoculture, as well as information on conferences and other events and new scientific publications. The necessity of a new periodical was determined, first of all, by the exigency of special scientific literature oriented towards the domestic market within the former Soviet Republics that was caused by the economic crisis in 1990s that resulted in the unprofitability of scientific books. The necessities to maintain a common scientific space for scientists in the former Soviet Union, as well as an English-language publication available to the majority of foreign readers who do not read Russian or the other languages of any of the other ex-Soviet Republics, were other important factors.

I am pleased to note that the AARFSU has fully met these tasks. This periodical has become widely known abroad and is available in the main libraries of the Russian Federation.

At the same time, possibilities for the publication of scientific articles in the ex-Soviet Republics and especially in Russia, have improved notably during the last ten years. The total number of publications on amphibians has increased about twice. Some new non-periodical issues in herpetology have appeared in regions of Russia. Several regional and international conferences have been held. A few monographs have been published in Russia, Ukraine, Belarus and abroad, including those in English and German, which makes them available to foreign readers.

The format of monograph becomes more and more attractive for authors and readers of the AARFSU. Since the fourth volume, its issues are often allotted for monographs that provide detailed information on different aspects of amphibian biology. It should be noted that the publication of books as separate issues of a periodical is a good tradition that existed in the Russian Empire; recall the classical works by A.A. Strauch and A.M. Nikolsky that were published as separate issues of the Memoirs de l'Academie Imperiale des Sciences de St.-Petersbourg.

Combining new tasks and old traditions, the AARFSU finally transformed into a publication of each volume in book format this year. These may be monographs as well as thematical collections of papers on particular aspects of amphibian studies. Our direction

remains the same as earlier – results of studies made by researchers from within the former Soviet Union as well as by foreign authors working within this region. All aspects of batrachology, as earlier, remain of interest.

Authors are fully responsible for the information presented. All the manuscripts will be peer-reviewed. Instructions for authors have changed somewhat relative to earlier issues. These changes concern only the format of the publications.

We hope that the new format of the AARFSU will attract new readers and will extend the circle of subscribers.

Sergius L. Kuzmin

Резюме. Земноводные Белоруссии. С.М. Дробенков, Р.В. Новицкий, Л.В. Косова, К.К. Рыжевич, М.М. Пикулик. В книге обобщены основные результаты долговременных исследований распространения, экологии и морфологии земноводных Белоруссии. Для всех видов земноводных: *Triturus vulgaris*, *T. cristatus, Bombina bombina*, *Pelobates fuscus*, *Bufo bufo*, *B. viridis*, *B. calamita*, *Hyla arborea*, *Rana temporaria*, *R. arvalis*, *R. ridibunda*, *R. lessonae* и *Rana esculenta* описаны географическое распространение, биотопическое распределение, структура ассамблей, питание, активность, размножение и развитие. Дается детальный анализ морфологической изменчивости и дифференциации доминантных видов. Обсуждаются региональные проблемы антропогенного воздействия и методология охраны видов.
Книга может быть полезна как для специалистов, так и для любителей.

Abstract. This book summarizes the results of a long-term investigation of amphibian distribution, ecology and morphology in the Republic of Belarus. For all amphibian species, *Triturus vulgaris*, *T. cristatus*, *Bombina bombina*, *Pelobates fuscus*, *Bufo bufo*, *B. viridis*, *B. calamita*, *Hyla arborea*, *Rana temporaria*, *R. arvalis*, *R. ridibunda*, *R. lessonae* and *Rana esculenta*, geographical and habitat distribution, assemblage structure, feeding, activity, reproduction and development are described. Detailed analysis of morphological variation and the differentiation of dominant populations by landscape regions are given. Regional problems of anthropogenic pressure and methodology of species conservation are discussed.
The book may be used by specialists and amateurs.

CONTENTS

СОДЕРЖАНИЕ

INTRODUCTION

Amphibians (Class *Amphibia*) represent one of the most ancient groups of terrestrial vertebrates that appeared in the Upper Devonian about 300 million years ago. The maximum diversity was achieved in the Carboniferous. The modern fauna includes more than 4800 species of amphibians, and the highest taxonomic diversity is represented in the humid tropics.

At the present, amphibians remain one of the least studied classes of vertebrates largely because of the absence of their evident practical value. The batrachofauna of temperate latitudes is not distinguished by high species diversity; only 15–20 species of amphibians are distributed in central Europe. Nevertheless, in many terrestrial and aquatic ecosystems this group plays an important role in secondary productivity and a connecting link between energy levels which provided functional stability. Amphibian tadpoles in shallow continental wetlands quite often play a very important role and dominate by number and biomass.

Because of some of their biological features, small size, short reproductive cycle, high population sizes and wide morphogenetic variability, amphibians became convenient objects for population studies. The development of batrachology promoted solutions to many theoretical problems and increased our knowledge of natural polymorphisms, microevolutionary processes, and principles of multi-species community organization, and various conservation problems.

The fauna of Belarus, which is situated in the mixed European forests zone, does not contain a high diversity of amphibians. There are no endemics, the majority of species has extensive ranges of distribution, and only few occur at range borders. Nevertheless, studies of this batrachofauna, which experiences the natural and climatic conditions, faunistic complexes, forms and scales of economic activities within the eastern European forest zone, are important.

The development of Byelorussian batrachology has a rather short history, and the first studies were bound to the interests of individual researchers. The first morphological descriptions of several species from Belarus were written by the well-known Russian herpetologist A. M. Nikolsky (1905, 1918) at the beginning of 20th century and based on museum collections. In 1924–1929 complex zoological studies, and particularly the collection of batrachological specimens, were organized by Professor A. V. Fedyushin of the Byelorussian State University. He made a series of expeditions to different regions of the Republic (e.g. Fedyushin, 1933). After World War II, studies of amphibians were

conducted by Yu.F. Sapozhenkov, who made the first complete species list and provided a general evaluation of amphibian geographical distributions. In those years, the fauna of nature reserves was investigated most intensively: Belovezhskaya Pushcha and Berezinsky Nature Reserves were studied by A.G. Bannikov, Z.V. Belova, B.I. Golodushko, T.N. Kurskova and Yu.V. Dyakov. Amphibians of particular localities were studied by O.G. Rodionenko, A.P. Krapivny, M. Kroshchenko and K.T. Nedelin who made ecological and morphological descriptions as well as identified the diets of some species.

Special works in the 1980s were initiated by M.M. Pikulik, who was the head of a group of explorers at the Institute of Zoology of Byelorussian Academy of Sciences, where L.V. Kosova, K.K. Ryzhevich, S.M. Drobenkov, R.V. Novitsky, A.D. Yasyulya and others are working (Fig. 1). The main directions of scientific studies during those years emphasized phenotypic variation in populations, analysis of landscape and habitat dispersal, and ecological features. In the same period considerable collections that represented samples from different regions of the Republic were made. At present, they include more then 15,000 specimens. Investigations of the regional batrachofaunas also were conducted by scientists at some universities and reserves (V.A. Bakharev, A.E. Padutov, Å.E. Padutov, A.V. Khandogii). From the 1990s, landscape herpetology (i.e., the degree of correlations the population structure and spatial differentiation of amphibians and reptiles with landscape heterogeneity of the territory) was actively developed by M.M. Pikulik.

The results of studies in this period were published in numerous scientific works and summarized in the monograph by M.M. Pikulik (Amphibians of Byelorussia, 1985), an

Fig. 1. Group of herpetologists at the Institute of Zoology, Academy of Sciences of Belarus.
From left to right: R.V. Novitsky, S.M. Drobenkov, M.M. Pikulik, L.V. Kosova, K.K. Ryzhevich and A.D. Yasyulya (photo in 2001).

encyclopedic directory (Amphibians. Reptiles, 1996), and special sections of the monograph "Effect of Radioactive Contamination on Fauna in Chernobyl Catastrophe Zone" (1994).

Considerable time has passed since these works appeared. In spite of an economic crisis in the Republics of the former Soviet Union in the 1990s, there has been high rates of urbanization and chemical contamination of habitats which have caused habitat degradation and a reduction of animal numbers. For that period after the appearance of the first special report on amphibians of Belarus, a great number of new studies were conducted, and it seemed necessary to generalize and analyze this new information. As a central problem of batrachology, as well as for the other fields of zoology, at the present stage of research, development of the study and conservation of the biological diversity of the fauna on the boundary of the 3rd millennium is imperative.

This monograph is the joint work of several researchers at the Institute of Zoology of the National Academy of Sciences of Belarus. The main purpose was to analyze the original data concerning distribution, ecology and morphology of the amphibians of Belarus. The primary questions are reflected in titles of the chapters and sections. General editing of the manuscript has made by S.M. Drobenkov. The authors tried to provide the most complete list of all works published in this field. The book is illustrated by photographs of all species, their typical morphotypes, possible anomalies and typical habitats. All data and pictures are from Belarus, and thus the name of the Republic is not indicated in the figure legends; otherwise, the names of other countries are indicated.

The authors would be grateful to anyone who provides remarks concerning the contents of the book to the following address:

Institute of Zoology of NASB, Akademicheskaya Street 27, Minsk 220072 Belarus.
E-mail: Bel_gerpetology@rambler.ru (Sergei Drobenkov)
nramphi@male.ru (Ruslan Novitsky)

Chapter 1.
MATERIALS AND METHODS

The basis of the work comprised the materials collected by the authors in 1978–2002 during field studies in the territory of Belarus and adjoining parts of the adjacent countries (Fig. 2). Longer studies were done at several localities in various regions of the Republic that represent all the nature-climatic conditions and influences of anthropogenic factors.

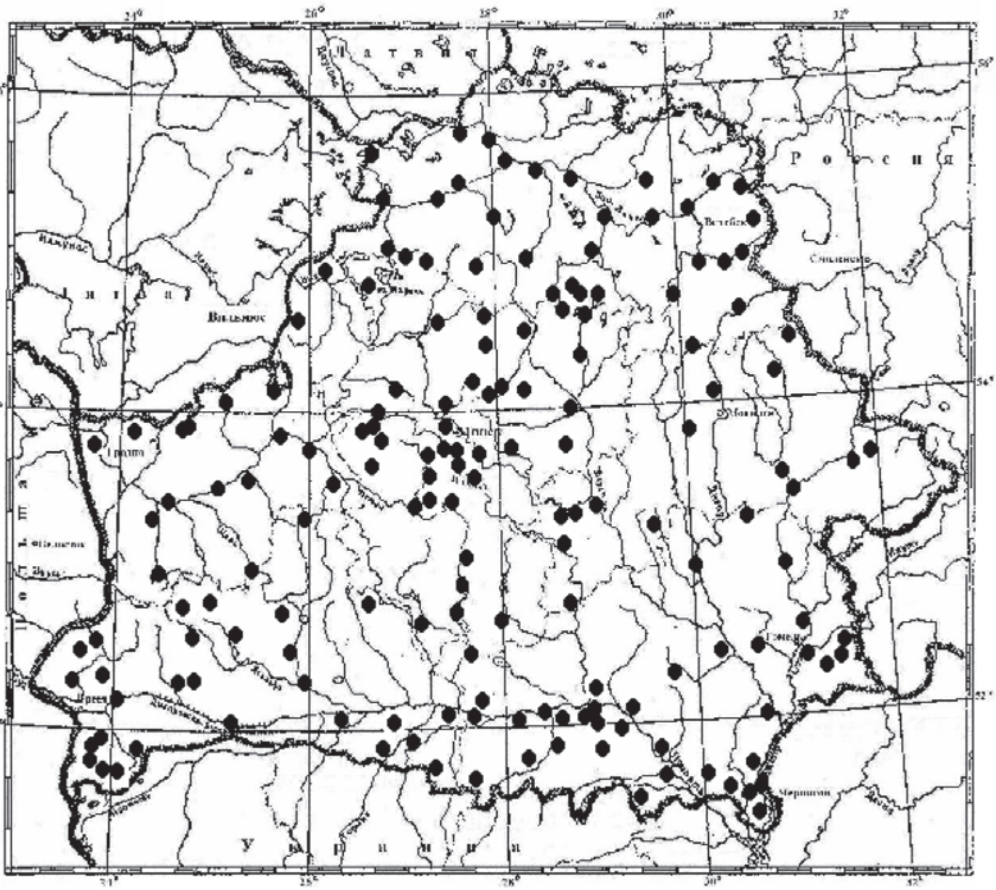


Fig. 2. Sites of batrachlogical research projects and the zone of distribution of amphibians in Belarus with small ranges.

In order to study the dominant amphibian and geographical variability, expeditions were made to the valleys of the largest rivers of Belarus (Pripyat, Dnieper, Zapadnaya Dvina, Neman and Berezina).

We used commonly accepted methods of collecting and treatment (Terentjev, 1950; Bannikov et al., 1977; Szczerbak and Szczerban, 1980; Pikulik, 1985; Garanin and Panchenko, 1987; Kuzmin, 1999; Lada and Sokolov, 1999). To obtain more precise data in some cases, comparative estimations of efficiency of various methods were done, and some updates were made. Species identification of adult and larval amphibians followed Bannikov et al. (1977) and Kuzmin (1999).

The typology of amphibian habitats is based on vegetation classification suggested for the territory of Belarus (Yurkevich et al., 1979). To reveal the structural organization of faunistic complexes (assemblages) of amphibians in various geobotanical subzones of the Republic, the landscape-ecological profiles crossing a "typical" range of ecosystems along a hydrothermal gradient were studied at permanent plots. The descriptions of model plots included more than 20 ecological parameters: location, configurations and square of site, adjoining ecosystems, types of trees, shrubs and grass vegetation, characterization of microclimatic regime, distance and parameters of water bodies, and anthropogenic factors. Population structure and abundance of amphibians were estimated by repeated route censuses.

Censuses of amphibians in ground and riparian habitats were done by linear transects during the time of maximum activity of animals (Kashkarov, 1927; Dinesman and Kaletskaya, 1952). The length of the routes within the limits of homogeneous habitat was not less than 400–500 m; the width, depending on height and density of grass cover, light exposure and other conditions, varied from 1 to 6–8 m. Quantitative estimations of metamorphs in places of mass emergence were done using the biocenometric frame measurement with further calculations of density (specimens/m^2; (Inozemtsev, 1969). Individual results were based on routes with variable transect widths. More exact data about number (density) were based on repeated total captures (or marking) and also by the mark-recapture method (Caughley, 1977).

Amphibian biomass in terrestrial ecosystems was estimated by two methods.

1. Direct weighing of all animals found on a plot.

2. Calculations based on average parameters of mass of individuals of various size-age classes and their relative abundances in samples, and total number of population.

We used individual toe-clipping for studies of the directions and extent of seasonal migrations, rates of growth and number of local groups (Martof, 1953). For studying the dynamics of diurnal activity during summer, repeated censuses were made on control plots for 1.0–1.5 days with an interval of 2 h.

Morphological measurements were made with vernier calipers to 0.1 mm. Amphibians were caught during searches of habitats and capture by net in reservoirs and sometimes

with traps and drop-cans. Some animals were fixed in the field in 2–3% formaldehyde solution, and they were transferred to 76% alcohol after 1–2 months.

For the study of morphological variability of amphibians, more than 20 traditional (Terentjev and Chernov, 1949; Terentjev, 1950; Bannikov et al., 1977; Kuzmin, 1999; Berger, 1966) and some original methods were used.

The following standard designations of morphometric parameters were used: L – body length; L.c – head length; Lt.c – head width; D.r.o – snout length; Sp.c.r – distance between internal edges of dark nose stripes; D.n.o – distance from a nostril to the front side of eye; L.o – maximum length of eye; Lt.p – the maximum width of the upper eyelid; Sp.p – distance between eyelids; Sp.n – distance between nostrils; L.tym – maximum length of the tympanic membrane; F – thigh length; T – shin length; D.p – length of the first toe; C.int – maximum length of the inner metatarsal tuber; and m – mass.

Subspecific names follow S.L. Kuzmin (1999).

Material for studying intraspecific variability and population differentiation of brown frogs (*Rana arvalis* and *R. temporaria*) were collected in 1978–1986 in various landscape zones. We analyzed variability of 13 morphometric characters and 12 body proportions most frequently used in taxonomy of brown frogs (Bannikov et al., 1977; Ishchenko, 1978). Also we investigated the variability of 20 phenotypes that reflect specific features of individual genetic constitutions whose frequency of occurrences are characteristic of populations (Timofeev-Resovsky et al., 1973). Analysis of the phenotypic structure of populations was done by frequency of occurrence of phenotypes (%) in samples from each population. In total, 50 samples of the Moor Frog (4870 individuals) and 45 samples of the Common Frog (2559 individuals) including mature individuals of both sexes were analyzed.

Numbers of eggs in a clutch were counted or estimated by the volumetric method extrapolating the data of the weight of an egg sample to the weight of the entire clutch. For some species, estimates of the number of ovarian eggs were done on preserved materials. Morphological features of reproductive organs were recorded during the study of gonads. During the estimation of ecological characteristics of breeding reservoirs, 17 parameters were recorded: form, area of water body, depth, flow, structure of the shore zone, adjoining ecosystems, degree of opacity, presence of aquatic vegetation, temperature regime, water pH, anthropogenic factors, and species commonly reproducing amphibians. Stages of anuran larvae were identified by Terentjev (1950), and stages of caudate larvae were determined from Glaesner (1925), Vorontsov et al. (1952), and Liozner (1975).

The diet was described on the basis of dissections of digestive tracts of animals preserved at the place of capture and also washing food items from the stomachs (Pisarenko and Voronin, 1976; Legler and Sullivan, 1979; Opatrny, 1980). Taking of food samples was dated for the period of the maximum stomachs filling (for the majority of species during summer period at 2100–0100 h). Separate data on feeding were recorded from direct observations in natural conditions. Special attention was given to the diet in the most

typical habitats. The diet was analyzed for 1850 individuals of amphibians, and more than 6700 food objects were recorded. The sample size was not less than 20–25.

The trophic niche width was estimated by values of the polydominance index (Simpson's formula)

$I = (p_i^2)^{-1}$,

where p_i is the share of i^{th} object from the total number of prey.

Overlapping of trophic niches by prey taxonomic structure was estimated by the Morisita index of similarity

$I = 2\, p_{ij} p_{ik} / ?\, (p^2_{ij} + p^2_{ik})$,

where p_{ij} is the share of i^{th} component in the diet of j^{th} species; p_{ik} is the share of i^{th} component in the diet of k^{th} species.

Pearson's distance was used as a measure of distance in a cluster analysis of amphibian assemblage structure.

Mathematical data processing was conducted using standard statistical methods (Lakin, 1980) with standard computer programs. Probability of casual distinction of average sizes was estimated using the Fisher-Student criterion. Distinctions were considered significant at $p \leq 0.05$. The multivariate analysis of phenotypic variability was done by mean population values of all characters and proportions using the main components method with preliminary normalization and centering. Significance of the contribution of each character to a given component was estimated by the t-criterion. With the algorithms developed by cluster analysis (Elkin and Ishchenko, 1979), for 14 population samples of the Moor Frog by population mean values of proportions of hind legs, statistical distances with the others were calculated. Multivariate estimation of the degree and structure of intrapopulational variation was done by parameters of an average phenotypic number ( ) and shares of rare phenotypes (h). The degree of similarity of populations was determined by the parameter of similarity (r), by the average phenetic distances between pairs of populations and by the sums of average phenetic distances of each population with all the others (Zhivotovsky, 1991). Significance of differences was estimated using the identity criterion (I) and the criterion χ^2.

Some special methodical approaches are described in more detail in corresponding sections.

Chapter 2.

Physical and geographical characterization of Belarus

The Republic of Belarus is positioned in the southeastern part of the Eastern European (Russian) Plains between latitudes 51° and 56°N and longitude 23° and 32°E. In the northwest, Belarus borders Lithuania and Latvia, in north and east it borders the Russian provinces of Pskovskaya, Smolenskaya and Bryanskaya, in the southeast and south it borders the Ukrainian provinces of Chernigovskaya, Kievskaya, Zhitomirskaya, Rovenskaya and Volynskaya, and in the west it borders Poland. From north to south the Republic extends 560 km, and from east to west it extends 650 km. The total area is about 2076 thousand km^2 (Encyclopedia of Nature of Byelorussia, 1986).

Belarus is positioned in the temperate zone and its climatic features are influenced by cold continental air masses coming from the Middle Russian Plains and boreal maritime air from the Atlantic Ocean. The total insolation of 85–97 $kcal/cm^2$ gradually increases from the north to south. Temperatures gradually decrease southwest to northeast. Climate continentality increases from west to east. The transition from winter location of isotherms to summer ones arrives more or less simultaneously throughout the territory: in the spring (April) and autumn (the end of September; Shklyar, 1973).

In the mountains and in northern parts of the Republic, there are 180–194 rainy days annually and 160–180 rainy days in the south and east. In dry years the amount of precipitation decreases to 300 mm, but in wet years it can exceed 1000 mm. Snow cover occurs mainly in December, but in November in the northeastern sector. The length of the snow season is about 2–4 months. In warm winters, because of frequent and intensive thaws, the snow cover disappears in some places. Finally, the snow melts in March in the southwest and in the middle of April in the northeast. Summer air temperatures are moderate and only in some days do they reach 35–38°C in June and August. The growing season (number of days with temperature above 5°C) is 209 days in the southwest and 175–180 days in the northeast.

Belarus is largely flat with complicated systems of patches, hills and mountains usually separated by valleys of small and large rivers. The average elevation is 159 m (85–346 m). The present surface was formed by actions of continental glaciers repeatedly approaching during Anthropogenic Epoch and the subsequent conversion of the glacial relief under natural and technogenic influences. Based on the influence of glaciations, the following

regions be identified: Byelorussian Poozerie, Byelorussian patch Predpolesie and Byelorussian Polesie.

The following subdivisions of Belarus are subtaiga (blended-wood) and Polesie (leaved forest) landscapes and 5 landscape provinces:

I – Poozerie, the zone of postglacial landscapes;

II – Byelorussian raised zone, hilly, morainal-erosion and morainal landscapes;

III – Predpolesie, a zone of secondary water-glacial and morainal landscapes;

IV – Eastern Byelorussian zone, secondary morainal influences of the landscapes;

V – Polesie, a zone of alluvial terraced, marshes and secondary postglacial landscapes.

Belarus is situated between the Black and the Baltic seas. The hydrographic network is well developed, and there are 20.8 thousand basins in the Republic, the greater part involving the river network. The total length of all rivers is 90,600 km. The largest rivers (more than 500 km) are the Viliya, Berezina, Neman (begins in Belarus), Soz, Pripyat, Zapadnaya Dvina, and Dnieper (transitional). The widths of the larger rivers reach 80–120 m. The average area of the river network is 44 km/100 km^2, and the rivers have variable volumes. In early spring the rivers are filled mainly by thawing, in winter they are fed by ground water, and in the remaining seasons rainfall and ground waters are important. At present, the majority of swampy areas have extensive drainage and polder systems. There are about 4000 lakes in Belarus with the majority concentrated in the northern part (Poozerie; Nature of Belarus, 1986).

The most widespread soils are turf-carbonaceous, turf-podzol, turf-podzol swamped, turf-paludous, peat-paludous (fen mires, transition, peat bog), floodplain (alluvial) peat- and peat-paludous. Turf-podzol and turf-podzols of water-logged soils prevail. They cover 68.3 and 22.3% of arable grounds, respectively, and have low natural fertility. The three edaphic provinces (Nature of Belarus, 1974) are:

I – Boreal (Baltic);

II – Central (Byelorussian); and

III – Southern (Polesie).

Each of these is divided into edaphic-climatic districts with names that depend on their geographical position, prevailing bedrocks and their combinations. Borders of the edaphic provinces are extended in latitudinal directions.

Belarus is situated on the border of two geobotanical zones: Eurasian coniferous (taiga) forests and European broad-leaved forests (Vegetation Cover of Byelorussia, 1969). A considerable amount of taiga plants, representatives of broad-leaved forests of Western Europe and steppes are typical for the flora. The vegetation cover displays clear zonality. From the north, the boreal flora, West-European and plots of forest steppe are replaced by broad-leaved forests, and in the south there are dark coniferous forests. The southern border of the continuous distribution of the European fir-tree and alder, as well as the northern border of hardbeam, extends by the territory under consideration. The modern

natural vegetation cover occupies 67.1% of the Republic and is represented by forests (34.5%), meadows (17.2%), moors (12.4%) and shrubs (3.0%) (Yurkevich et al., 1979). According to the geographical position and differentiation of physical conditions, there is significant mosaicism.

The zonality of the vegetation cover is determined first by zonal features of the forest (Geltman, 1982). The forests occur mainly on sandy flats and swamped lowlands. There are some areas of large trees, but there are no treeless regions.

According to the complex geobotanical geographical regionalization (Vegetation Cover of Byelorussia, 1969), the area is divided into three geobotanical subzones: oak-dark coniferous forests, hardbeam-oak-dark coniferous, and broad-leaved-pine forests. Within the subzones, seven geobotanical districts are outlined. The geobotanical districts are divided into 25 smaller geobotanical districts bounding complexes of homogeneous vegetation.

The zones are peculiar not only for wood, but also for swamp-meadow vegetation. In the north, upland meadows dominate, which include high parts, watersheds and terraces above floodplains. In the south, fen-bogged meadows occur in the lowlands on watersheds and above the floodplains terraces dominate. Examples of amphibian habitats in different parts of the Republic are shown in Plate 14.

Thus, the significant differentiation of the territory based on physiographic, climatic, hydrological, edaphic, floristic and landscape units determines complex of ecological factors influencing the state of animal population.

Belarus has extensive development of industry, agriculture, fast growth of cities and human population, high density of transport networks, increasing intensity of transport movement, increasing level of extraction of useful mineral resources and industry, development of tourism, and other forms of recreation (State of Environment of Belarus, 2001). The natural and altered vegetation covers 38% of the territory, and its anthropogenic transformation continually increases.

Anthropogenic pressure produces essential effects on nature. The degree of differentiation, "insularization" and isolation of ecosystems are increasing, connections between ecosystems are breaking and, as result, the stability of populations is reduced. Also, the, effects of pollutants of anthropogenic origin on ecosystems continually increases. The anthropogenic pressure has its maximum effect in the central part of the country that is most densely populated and in the eastern part (Mogilevskaya Province) has been converted to agriculture. Intensive land modifications have occurred in northern regions of Byelorussian Poozerie and in the south in Byelorussian Polesie.

At present, the following factors most negatively influence the amphibian fauna of Belarus:

1) transformation of habitats;
2) chemical pollution of habitats; and
3) intensification of transport movement.

In 1986, as a result of the accident at the Chernobyl Nuclear Electric Power Plant, about 3.5% of the material from the radioactive decay has been deposited in the environment, and more than 70% of the radiocontamination has been deposited within Belarus. The majority the southeastern part of Belarus was polluted. The isotope composition of anthropogenic origin is represented by radionuclides with a different half-lifes and biological activities (^{134}Cs, ^{137}Cs, ^{90}Sr, ^{144}Se, ^{240}Pu, ^{25}Sb, ^{107}Ru). The major radionuclides that are biologically dangerous are ^{134}Cs, ^{137}Cs and ^{90}Sr. The isotope ^{137}Cs composes up to 90% of the radioactivity in all polluted territories. The density of radiopollution in some places reaches 40 Ku/km^2 (Fauna in Zone of the Accident of the Chernobyl NP, 1995).

CHAPTER 3.
SYSTEMATIC OVERVIEW

The Recent batrachofauna of Belarus is represented by 2 species of Caudata and 11 species of Anura that belong to 6 families. There are no endemics, and the majority of the species has extensive Palaearctic or European distributions. Natterjack Toad, Common Tree Frog and Fire-Bellied Toad have limited distributions. They occur only in the southern or southwestern parts of the Republic. The complex of green frogs includes 3 species: Marsh Frog, Pool Frog and their hybrid form, Edible Frog. However, because of the difficulty of species identification, their distribution in Belarus is still not investigated. At present, only one exact locality is known where Edible Frogs live: the ponds of the fish-farm "Alba" in Nesvizhskii District (central part of the Republic). This site was found as the result of analysis of several population samples by blood serum albumin electrophoresis (Pikulik, 1985). The Common Frog has an interesting distributional feature. In the Pripyat floodplain there is a vast zone where this species is absolutely absent.

Order CAUDATA

Family SALAMANDRIDAE

Genus *Triturus*

Smooth Newt, *Triturus vulgaris* (Linnaeus, 1758)

Color Plate 1.

The geographical range of the Smooth Newt covers almost all of Europe, except southern France, Portugal and Spain, northern Scandinavia and the steppe regions of Russia and Ukraine. The northern limit of the distribution area occurs in northern Russia and reaches Eastern Siberia (Krasnoyarskii Region); another part is situated in the Caucasus (Kuzmin, 1999). Throughout Belarus, the Smooth Newt is widespread and common (Fig. 3).

Seven subspecies of the Smooth Newt are known (Kuzmin, 1999). In Belarus and in adjacent regions the nominative subspecies, *Triturus vulgaris vulgaris* (Linnaeus, 1758) occurs.

The Smooth Newt belongs to the group of small newts (subgenus *Palaeotriton*). Length of the body (L.+L.cd.) of adults from Belarus does not exceed 101 mm (Table 1). The body of

Fig. 3. Distribution of *Triturus vulgaris* in Belarus.

Table 1. Size and body proportions of *Triturus vulgaris* from the territory of Belarus (n=204).

Characters	Values	
	M ± m	**Lim**
L	35.67 ± 0.21	28.3 – 51.0
L.cd	37.54 ± 0.27	24.0 – 50.0
L.c	6.06 ± 0.03	4.9 – 7.3
Lt.c	5.97 ± 0.05	4.9 – 7.4
P.a	12.2 ± 0.08	9.2 – 15.7
P.p	12.27 ± 0.08	8.7 – 16.0
L/L.cd	0.96 ± 0.01	0.75 – 1.42
L – L.c/L.c	4.82 ± 0.03	3.43 – 6.5
L/L.c	5.82 ± 0.03	4.43 – 7.5
P.a/P.p	1.0 ± 0.0	0.76 – 1.21
L/P.a	2.89 ± 0.02	2.25 – 3.6
L/P.p	2.88 ± 0.02	2.25–3.83
L/L.tc	5.91 ± 0.04	4.97 – 7.11
M	1.7 ± 0.03	0.75 – 3.4

adult newts is brown, brownish-grey or brownish; the belly is light yellow with small or medium-sized spots. A dark longitudinal stripe extends through the eye. In the mating period the central part of a belly is orange, and males acquire a scalloped crest and white-blue stripe on each side of a tail. The skin is smooth and in females it is sometimes finely granular. Males are a little larger than females and have a more prominent cloaca. At water temperatures greater then 18–20°C, after completion of the mating season, male breeding color and notched crest disappear rapidly. The sexual dimorphism in the Smooth Newt proved to be not reliable statistically by the majority of the main morphometric parameters studied.

After hibernation, Smooth Newts appear usually in the first week of April or the end of March (first encounters: 29–30 March). Water temperatures at that time were 5–10°C, and many water bodies were still covered with ice. Peak breeding was observed from the end of April to the middle of May. However, some individuals deposit eggs to the end of June and beginning of July.

Natural or artificial shallow, well warmed water bodies, with light flow or ditch water, serve as breeding habitats. These are puddles in woods, pits and roadside ditches filled with water, waterside areas of ponds and lakes, drainage channels, and transitional bogs and fens. In spring, this species may be observed in almost all wetlands. In some cases it breeds even in rather deep (more than 1 m) water bodies but keeps to the littoral zone.

Maximum densities breeding population of Smooth Newt can reach 10–12 specimens/m^2. The ratio of males and females in 9 samples was 1.1:1 (n = 238). The spring activity patterns do not show the nocturnal peak that is rather typical for the Crested Newt.

The breeding performance of the Smooth Newt is rather insignificant, and the number of eggs per female varies from 70 –190. Eggs occur by one or small numbers of 3–7. Spawning is accompanied by courtship when a male undulates by tail, actively demonstrates bright coloration on his sides to the female, touches its body, and sometimes does quick movements and jerks to the sides. In the final phase, the male deposits a spermatophore on underwater subjects which female picks up with her cloaca. During eggs laying, which lasts some days, female wrap every egg in a leaf of an aquatic plant with the hind legs.

The embryonic development at water temperatures of 15–20°C takes 12–18 days. Larvae, in the contrast those of the Crested Newt, do not float in the water column and stay in aquatic patches of plants. Body lengths of metamorphs (L+L.cd) range from 19–34 mm. In some regions, neoteny (breeding in a larval state; Litvinchuk et al., 1996) occurs.

In summer after the end of breeding, the Smooth Newt occurs in shady habitats and prefers humid deciduous and mixed forests. The population density in the most favorable habitats can reach 5–8 specimens/100 m^2. While moving onto land, it settles not far from wetlands and selects areas with a poorly developed grass canopy and mellow soil. In the terrestrial phase, it spends the majority of time in the soil layer or leaf debris and comes to the surface only at night. It hibernates on land near wetlands, either alone or in small groups of 3–8 individuals.

Invertebrates (Odonata larvae, larvae and adults of Dytiscidae and Hydrophilidae) compose its main food in the aquatic phase. In some cases the newt preys on vertebrates (tadpoles of green frogs), and feeding does not stop during the breeding period. Larvae consume mainly planktonic animals. When the Smooth and the Crested newts are syntopic, larvae and adults can be prey of larger species. Larvae and adult newts are eaten also by aquatic invertebrates (dragonflies larvae, diving beetles), some species of fish and mammals and birds (storks, herons, ducks) (Garanin, 1964; Szczerbak and Szczerban, 1980).

The Smooth Newt is rather resistant to various anthropogenic factors. It is common in urban areas, even in large cities such as Minsk. However, urban populations of newts are not large. Total bog reclamation, chemical pollution of water, highways building and increasing traffic are unfavorable for these populations.

However, in some cases the same economic activities render positive effect on the state of population. Most usual breeding habitats of Smooth Newt in the anthropogenic landscape are ditches along roads and sand pits filled up by flood waters. The creation of drains with light flow also promotes local increases of populations.

Great Crested Newt, *Triturus cristatus* (Laurenti, 1768)

Color Plate 2.

The distribution of the Crested Newt includes all of Europe, except in the southern and northern parts, and Asia down to the western part of West Siberia (Kuzmin, 1999). In Belarus, it is widespread but is distributed irregularly (Fig. 4).

Earlier the presence of four subspecies within *T. cristatus* was determined, but during special studies in recent years with the use of biochemical analysis, these subspecies are placed as independent species in the superspecies *T. cristatus* (Litvinchuk et al., 1994; Litvinchuk, 1998). In Belarus, the nominative subspecies, *T. cristatus cristatus* (Laurenti, 1786), occurs.

The Crested Newt belongs to the group of large newts (subgenus *Triturus*). The maximum size of individuals from Belarus (L+L.cd) does not exceed 160 mm (Table 2). The body is black, brownish-black or dark gray with more dark spots, and the belly is orange with black spots of different shapes and sizes. In the breeding season males have a well-developed, scallopped crest on the back and tail. The crest is interrupted at the base of the tail. Each side of the tail has a bluish-white stripe with a pearl tint. The cloaca of the female is flat and orange-red in color. The integument is coarsely granular.

In the aquatic phase it lives in ponds, lakes, rivers, their former beds and backwaters, drainage channels and other wetlands with slow flow or ditches with permanent aquatic vegetation. The depth of these wetlands is, as a rule, 0.6–0.9 m, although this species also occurs in temporary pools with maximum depths of 20–30 cm, sometimes more than 1.5

Fig. 4. Distribution of *Triturus cristatus* in Belarus.

Table 2. Size and body proportions of *Triturus cristatus* from the territory of Belarus (n=89).

Characters	Values	
	M ± m	Lim
L	67.58 ± 0.93	47.6 – 80.0
L.cd	51.38 ± 0.96	31.0 – 77.0
L.c	14.06 ± 0.3	7.7 – 20.0
Lt.c	12.45 ± 0.44	8.20 – 17.0
P.a	18.30 ± 0.7	11.0 – 26.0
P.p	20.4 ± 0.28	14.1 – 26.0
L/L.cd	1.23 ± 0.02	1.0 – 1.9
L – L.c/L.c	4.41 ± 0.08	2.76 – 7.02
L/L.c	5.34 ± 0.09	3,76 – 8.2
P.a/P.p	0.92 ± 0.04	0.52 – 1.17
L/P.a	3.57 ± 0.02	2.61 – 5.84
L/P.p	3.12 ± 0.04	2.61 – 3.48
L/L.tc	6.64 ± 0.14	5.80 – 7.82
M	7.09 ± 0.53	3.0 – 11.6

m. Quite often it lives together with the Smooth Newt, but the occurrence and number of this species in Belarus is much lower. Maximum density in breeding aggregations in optimal habitats can reach 8–10 specimens per 20 m^2.

After hibernation, it appears in the second half of April at water temperature above 11–13°C. The breeding season of the Crested Newt starts at the end of April, its peak falls on the middle to end of May. However, some individuals deposit eggs at the beginning of July. Sometimes adult newts stay in wetlands to the middle of August. The sexual composition of breeding groups is dominated by females that comprise 65–80% (8 samples, 211 specimens) of specimens. In the spring it is active mainly during the warmest time of the day. In summer the greatest activity is during the first half of the night (2100 to 0200 h) when a majority of a population moves to warm shallow water where individuals actively forage and breed.

The male courtship resembles that in the Smooth Newt. Taking a position near the female's head and crooking his body and a tail, the male undulates his tail. Very often 3–4 males gather near one female. Females pick up a spermatophore with the cloaca and transports to the spermatheca. When spawning, the female wrap each egg in a leaf of an aquatic plant or attaches it to the lower sides of leaves.

Crested Newts lay 150–265 eggs. The embryonic development in natural conditions at water temperature of 15–21°C takes 2–3 weeks. Larva differs from that of the Smooth Newt by a longer filiform outgrowth of the caudal fin. It has a pelagic mode of life. Long and thin digits and fins occur. The size of metamorphs at the end of July reached 38–65 mm. In some parts of its distribution (Germany, Moldavia, Ukraine, Russia) neotenic individuals that hibernate and are capable for breeding are known.

In the terrestrial phase Crested Newt are mainly nocturnal. In the afternoon it hide itself in leaf debris, soil surface layers, tree butts, under snags and in other shelters. They occur in wet deciduous or mixed forests, preferring oak and grey alder woods; in the open places they are seldom encountered. Maximum densities in optimum habitats can reach 3–10 specimens/1 m^2, however, the average seldom exceeds 3–5 specimens/100 m^2.

The main food of the Crested Newt larvae are hydrobionts (*Daphnia*, maggots), but Smooth Newt and some other amphibian larvae are eaten. Adults in the terrestrial habitats consume various invertebrates, gastropods, insects and others. The feeding does not cease in the breeding period. These amphibians are eaten by grass snakes, common toads and some birds (Kuzmin, 1999).

In comparison with other amphibian species, anthropogenic factors have more of a negative effect on Crested Newts. To some extent this is explained by its greater sensitivity to chemical pollution of breeding pools. In comparison with the Smooth Newt, it is considerably rarer in large cities. Together with the Tree Frog, it is the most favorite object for keeping in terraria. It is collected quite often in the cities and suburban areas for this purpose. Among the natural factors, the greatest effect on populations of this species state is caused by the processes of overgrowth and eutrophication of wetlands and their drying that result in the loss of all larvae.

Order ANURA

Family DISCOGLOSSIDAE

Genus *Bombina* Oken, 1816

Fire-Bellied Toad, *Bombina bombina* (Linnaeus, 1761)

Color Plate 3.

The geographic range of the Fire-Bellied Toad covers Central and Eastern Europe to the Urals and Asia Minor (Kuzmin, 1999). In Belarus, the northeastern limit of this species distribution is situated to the south of the towns of Postavy – Dokshitsy – Novolukoml – Orsha (not higher than 55°N; Pikulik, 1985). The distribution is shown in Fig. 5.

The Fire-Bellied Toad is one of the smallest species of European amphibians. Its length body does not exceed 50 mm (Table 3). The color of the body is grey, grayish-brown, green

Fig. 5. Distribution of *Bombina bombina* in Belarus.

Table 3. Size and body proportions of *Bombina bombina* from the territory of Belarus (n=170).

Characters	Values	
	M ± m	Lim
L	34.6 ± 1.12	19.7 – 49.4
L.c	8.71 ± 1.54	6.2 – 9.9
Lt.c	13.42 ± 0.83	11.0 – 16.2
L/L.c	3.83 ± 0.56	3.1 – 4.5
L/T	2.94 ± 0.46	2.75 – 3.2
F/T	1.01 ± 0.24	0.9 – 1.05
m	4.14 ± 1.01	0.53 – 11.97

or black with white dots. The belly is usually red or orange with large black or bluish spots of different shapes. The skin is covered with small warts that secrete toxin. Males have a pair of internal vocal sacs and dark nuptial pads on the 1^{st} and 2^{nd} fingers and on the inner side of the forearm. Webbing is poorly developed. No clear sexual dimorphism of majority characters of external morphology has been found.

The subspecific differentiation is unclear. The belly coloration within Belarus is very variable (Novitsky et al., 2001).

This species is associated with aquatic environments during the entire activity period. It inhabits a wide spectrum of water bodies: temporary puddles, ponds, moors, former river beds, drainage channels, shallow-water parts of lakes, storage basins and fishery ponds. Quite often it is found in pools with the area of 1–2 m^2, for example, ditches, woodland puddles and road gauges. It occurs both in open and wooded landscapes, and it does not leave wetlands which are filling with effluents from cattle breeding farms with high organic content. This is one of the most thermophilous members of the local batrachofauna and prefers shallow, warmed, light-flowing or still waters.

The Fire-Bellied Toad is active from April to September at water temperatures of above 10°C. The duration of activity is 165–180 days. The breeding starts at the end of April when the temperature of water rises to 15–17°C and ends at the end of June or the beginning of July. The peak falls in May.

The Fire-Bellied Toad does not form local aggregations in the breeding season. It is distributed over the whole area of water more or less evenly. Population densities in the summer vary from 2–3 to 35–50 specimens/100 m^2. In some wetlands, for example in fishery ponds, the number of toads reaches several hundred individuals. The ratio of males to females in the population (n=560) is 1:1.18.

Mating calls of the males are heard in the summer during the whole day and the first half of the night. Mating calls occur rhythmically as a melodious “unk” or “umm” uttered both from the surface and underwater. Male clasps female in the inguinal region during amplexus. Clutch sizes range from 90–520 eggs (most often 210–300). The eggs are deposited in packets of 5–30 eggs on underwater vegetation. The diameter of an egg is about 7–8 mm, and the length of a hatchling is 3.5–5.0 mm.

The duration of embryonic development at water temperatures of 18–21°C is 5–7 days. The tadpoles differ from those of other species by a wide tail fin. Tadpoles stay in mid-water, they are distributed evenly, and do not form large aggregations. The larval phase lasts 2.0–2.5 months. The tadpoles consume mainly tiny algae and aquatic plants and some plankton and worms. The metamorphs measure about 15 mm. Metamorphosis takes place mainly in July–August.

After metamorphosis, the Fire-Bellied Toad feeds on invertebrates. Hymenoptera (26.8%), Diptera (18.6%), Mollusca (14.4%) prevail in the diet. Feeding does not cease at reproductive period. Fire-Bellied Toads reach sexual maturity at body length of about 32 mm (minimal size of amplectant individuals). They reach such lengths seemingly after the third hibernation. Migration from basin to basin occurs during twilight, at night or during cloudy and rainy weather. The Fire-Bellied Toad overwinters in riparian areas of pools where they can ne found together with the Smooth Newt and the Moor Frog.

A specific defensive posture is typical. The toad turns ventral side up, crooks limbs and closes with the palms close to its eyes, and exposes the bright spots of the body. Dermal glands are toxic and produce physiologically active peptide substances (e.g., bombezine; Orlov and Gelashvili, 1985). Fire-Bellied Toad has evidently fewer enemies then other amphibians because of these toxic secretions and other methods of protection. Nevertheless, its tadpoles sometimes are eaten by Grass Snakes (*Natrix natrix*). The Fire-Bellied Toad is resistant enough to anthropogenic transformation of natural ecosystems and is encountered in wetlands in villages, settlements, cultivated landscapes, urbanized regions and even large cities. The greatest harm to the population is the destruction and chemical pollution of wetlands where the toad spends almost its entire life. Great losses of local population in the years 1960–1980 was caused by large-scale reclamation of swamped lands, especially in Byelorussian Polesie.

Family PELOBATIDAE

Genus *Pelobates* Wagler, 1830

Common Spadefoot, *Pelobates fuscus* (Laurenti, 1768)

Color Plate 4.

The geographic distribution of the Common Spadefoot extends from Central Europe to Western Siberia and Kazakhstan (Kuzmin, 1999). In Belarus it is distributed widely but irregularly (Fig. 6).

It is a medium-sized amphibian; body length of individuals in Belarus does not exceed 60 mm (Table 4). The upper surface of the body is grayish, grey-brown or brownish with small reddish dots. The forehead has large longitudinal convexities. The skin is smooth or slightly knobby. Well-developed toe webs are present, and the inner metatarsal tubercle is

large and spade-shaped. The eyes are large with a vertical pupil. Males differ from females by their smaller size, contrasting pattern on the back, and prominent oval glands on the shoulder. Small knobs appear on the palms and forearms of the males during the breeding period. Male vocal sacs are absent.

Fig. 6. Distribution of *Pelobates fuscus* in Belarus.

Table 4. Size and body proportions of *Pelobates fuscus* from the territory of Belarus (n=129).

Characters	Value	
	M ± m	**lim**
L	38.9 ± 2.01	31.0 – 60.3
L.c	14.65 ± 0.87	13.41 – 18.63
Lt.c	18.76 ± 0.76	14.53 – 23.54
L/L.c	2.66 ± 0.09	2.11 – 3.23
L/T	2.67 ± 0.16	2.51 – 3.02
F/T	1.11 ± 0.07	0.91 – 1.32
m	8.48 ± 0.09	2.37 – 19.03

Two subspecies of the Spadefoot were distinguished earlier, but the former USSR is inhabited only one of them (Kuzmin, 1999). Recently the Spadefoot was suggested to be a superspecies.

Spadefoots breed for 2-3 weeks in the second half of April to the beginning of May. It selects relatively deep bodies of water (1.0–1.3 m) with aquatic vegetation on the bottom. Mating calls of males resemble sudden, abrupt "toc-toc-toc" or "crok-crok-crok," which can be heard only for 30–50 m. Amplectant pairs stay underwater and do not appear to surface. They do not form breeding aggregations. Usually, no more than 15–20 pairs occur in one water body. The amplexus is inguinal.

Egg deposition occurs at water temperature of 12–20°C, sometimes a little lower. Spawn is laid on the aquatic plants at the bottom or in middle layers of water. Egg clutch has the shape of 1–2 thick sausage-like bars or cords up to 1 m long with eggs in 2–3 rows. It consists of 1250–3100 (most often 1600–1700) eggs. The duration of embryogenesis depends on the environmental temperature and is usually 6–9 (mean = 7 days. A prolonged period of larval development, which takes to 3.0–3.5 months, is typical. Tadpoles are very large, 70–160 mm long, and grew very fast. They differ from larvae of other species by having the spiraculum positioned on the left side and directed upward and back, and also they have high upper caudal fins with a pointed tip. The larva feeds on algae, detritus, and occasionally on invertebrates. The length of metamorphs is 10–25 mm. Metamorphosis occurs from the end of July till the beginning of September, more often in the middle of August.

The Spadefoot lives in coniferous, broad-leafed and mixed forests, in fields and meadows, and in gardens and settlements. It inhabits open habitats or modified forests. Mean population densities in terrestrial habitats range from 10–20 specimens/ha. Very high densities, 300–1200 specimens/ha are sometimes found inn meadows of polder systems, hydroelectric reservoirs, the shores of water storage basins, in agricultural areas, and dry pine forests. The ratio of males to females in combined samples from Belarus collected in different years and in different seasons was 1:1.38.

During dry hot weather in the summer, this species is active on the surface at twilight and the first half of the night and sometimes in cool or rainy weather. The Spadefoot conducts semi-fossorial life and thus prefers sandy soils. During the daytime it hides in holes which it digs with the hind legs. It hibernates in the soil at depths of 0.4–0.7, sometimes to 1.5 m. In cold weather it quite often found in wells and cellars near human settlements.

The food of adults consists mainly of insects: Diptera (34.5%), Lepidoptera (13.1%), Elateridae (6.7%), Coleoptera (4.7%, in particular, Curculionidae: 4.6%). It does not feed during the breeding season.

The Spadefoot has toxic dermal glands that produce secretions that irritate the nasal mucosa and evidently has relatively few enemies. One of the most important anthropogenic factors contributing to the decline of these populations is chemical pollution of breeding wetlands by industrial wastes, pesticides, and mineral fertilizers. There is information in

the literature on the high dependence of this species on the quality of water and soil during the breeding season (Kuzmin, 1999). In urban landscapes it occurs rather seldom. The increase of its populations in some regions of Belarus was promoted by some forms of agricultural activity (ploughing up of lands, building of polder systems) and the conservation of basins necessary for breeding.

Family BUFONIDAE

Genus *Bufo* Laurenti, 1768

Common Toad, *Bufo bufo* (Linnaeus, 1758)

Color Plate 5.

The distribution of the Common Toad covers Europe and a small part of East Siberia (Kuzmin, 1999). In Belarus, it is a widespread and in some places numerous (Fig. 7).

According to the modern taxonomic ideas, the Common Toad is a central member of the complex *B. bufo*, which consists of about 10 species. The systematics of this complex remains unclear. At present, three subspecies of the Common Toad that were found earlier on the territory of the former USSR are considered to be separate species (Kuzmin, 1999).

In its morphological and ecological peculiarities, the Common Toad is one of the most investigated species of Belarus. It is one of the largest species of local amphibians. Maximum length of the body of individuals from the Republic is 105 mm, the mass 143 g (Tables 5 and 6). The skin is covered with large blotches; parotid glands are big. The dorsum of the body is grey, grey-brown, brown or occasionally almost black and is covered with dark spots or stripes. Males in the breeding season have dark mating callosities on the 1st, 2nd and, sometimes on the 3rd finger. The belly is white, dirty-white or yellowish and covered with dark spots (Fig. 8). Subarticular tubercles on the toes are double. There is no longitudinal fold on the tarsus.

Table 5. Size and measurements of *Bufo bufo* from the territory of Belarus (n=531).

Characters	Males (n=353)		Females (n=178)	
	min – max	M ± m	min – max	M ± m
L	3.93 – 8.99	6.51 ± 0.043	4.781 – 10.5	7.68 ± 0.078
L.c	1.18 – 2.2	1.7 ± 0.009	1.29 – 2.63	1.96 ± 0.018
Lt.c	1.42 – 2.99	2.15 ± 0.015	1.67 – 3.53	2.59 ± 0.027
F	1.4 – 3.31	2.46 ± 0.02	1.63 – 3.88	2.71 ± 0.031
T	1.35 – 3.2	2.41 ± 0.018	1.53 – 3.52	2.62 ± 0.026
D.p	0.33 – 0.98	0.65 ± 0.006	0.37 – 1.0	0.64 ± 0.007
m	6.95 – 63.7	29.39 ± 0.937	10.6 – 143	74.7 ± 3.025

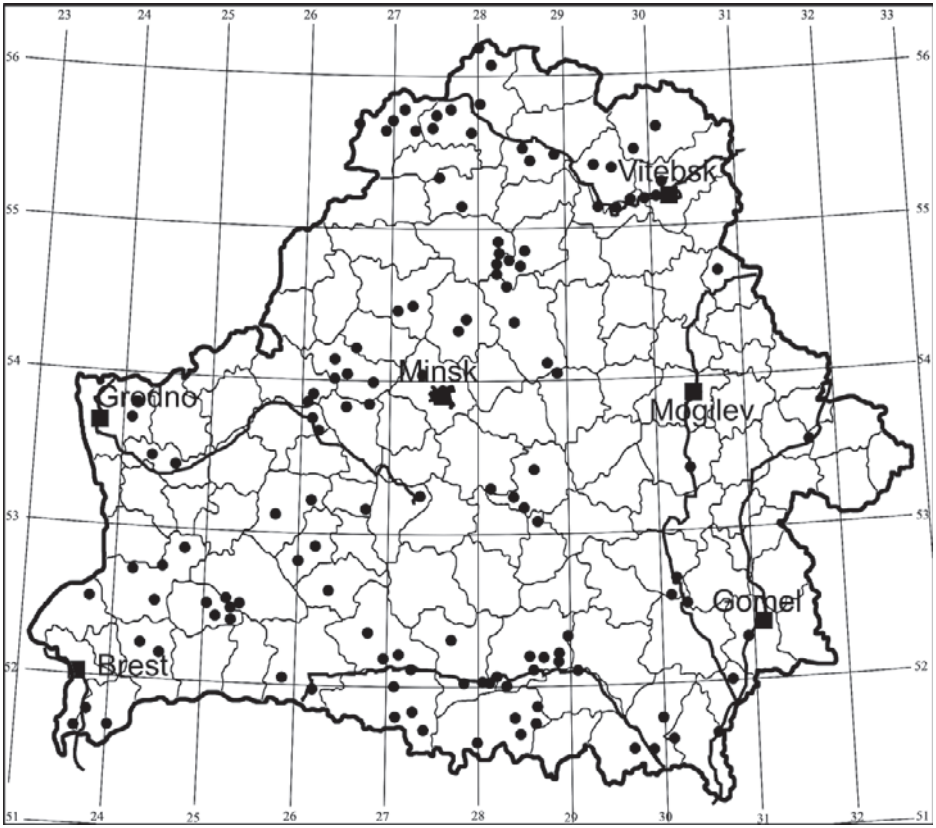


Fig. 7. Distribution of *Bufo bufo* in Belarus.

Fig. 8. Ventral surface of *Bufo bufo*.

The breeding of the Common Toad in the central part of the Republic occurs in the middle of April at water temperatures 6–14°C, usually a little later than the Common Frog and simultaneously with the Moor Frog. Wetlands with light flow or ditch-water, such as rivers, sloughs, drainage channels, ponds and water storage basins, serve as breeding habitats (Fig. 9). The spawn is deposited on underwater vegetation or on the bottom. The length of the spawn cord reaches 3 m and the eggs are arranged

Table 6. Body proportions of *Bufo bufo* from the territory of Belarus (n=531).

Indices	Males (n=353) M ± m	Females (n=178) M ± m
C.intl/c.inth	1.68 ± 0.021	1.72 ± 0.055
D.p/cintl	1.85 ± 0.024	1.55 ± 0.027
D.r.o/D.n.o	1.76 ± 0.026	1.75 ± 0.034
D.r.o/L.o	1.3 ± 0.017	1.27 ± 0.022
F/T	1.02 ± 0.011	1.04 ± 0.016
K	0.11 ± 0	0.14 ± 0
L/F	2.64 ± 0.028	2.83 ± 0.043
L/F+T	1.33 ± 0.055	1.44 ± 0.066
L/Lc	3.82 ± 0.033	3.92 ± 0.054
L/T	2.69 ± 0.027	2.93 ± 0.042
Lc/D.r.o	2.49 ± 0.028	2.61 ± 0.042
Lc/Lt.c	0.79 ± 0.007	0.76 ± 0.011
L-L.c/L.c	5.51 ± 0.196	6.68 ± 0.369
Lt.c/Sp.c.r	3.11 ± 0.028	3.09 ± 0.044
Ltim/L.o	0.4 ± 0.007	0.4 ± 0.02
Lt.p/Sp.p	0.99 ± 0.01	0.93 ± 0.014
Sp.c.r/D.r.o	1.01 ± 0.012	1.12 ± 0.018
Sp.c.r/Sp.n	1.74 ± 0.015	1.83 ± 0.036
Sp.c.r/Sp.p	1.26 ± 0.012	1.28 ± 0.018
Sp.p/Sp.n	1.38 ± 0.013	1.44 ± 0.028
T/C.intl	6.92 ± 0.081	6.32 ± 0.102
Lt.c/L	0.33 ± 0.003	0.34 ± 0.005
2T/L	0.74 ± 0.008	0.68 ± 0.01
Lt.c/Sp.p	3.93 ± 0.038	3.94 ± 0.057
2T/C.intl	13.84 ± 0.162	12.63 ± 0.204
Lgp/Lagp	1.91 ± 0.051	2.11 ± 0.062

in 1–2 series (Fig. 10). Spawn cords sink to the bottom at once and are seldom visible from the surface.

The mean density of breeding aggregations is about 7–10 specimens/20 m^2 of surface area (maximum to 5/m^2). Spawning toads periodically form aggregations of 7–20 males that clasp 1–2 females (and sometimes brown or green frogs). Cases of drowning of female during amplexus with several males are known.

In some places in spring during spawning there are large numbers of Common Toads. Territorial aggregations in a small area (2–4 km^2) may include 4–8 thousand individuals. Large associations are seen more often along river beds, sloughs, drainage channels, and the shores of water storage basins. Males do not have vocal sacs, but they can emit low intensity sounds that resemble “crum-crum” or “puff-puff.” Amplexus, as well as for the two other species of toads, is axillary.

Common Toads have one of the highest fecundities among all local species. The number of eggs varies from 3000 to 12000 (6445±680.8). The diameter of one egg is 1.5–1.7 mm.

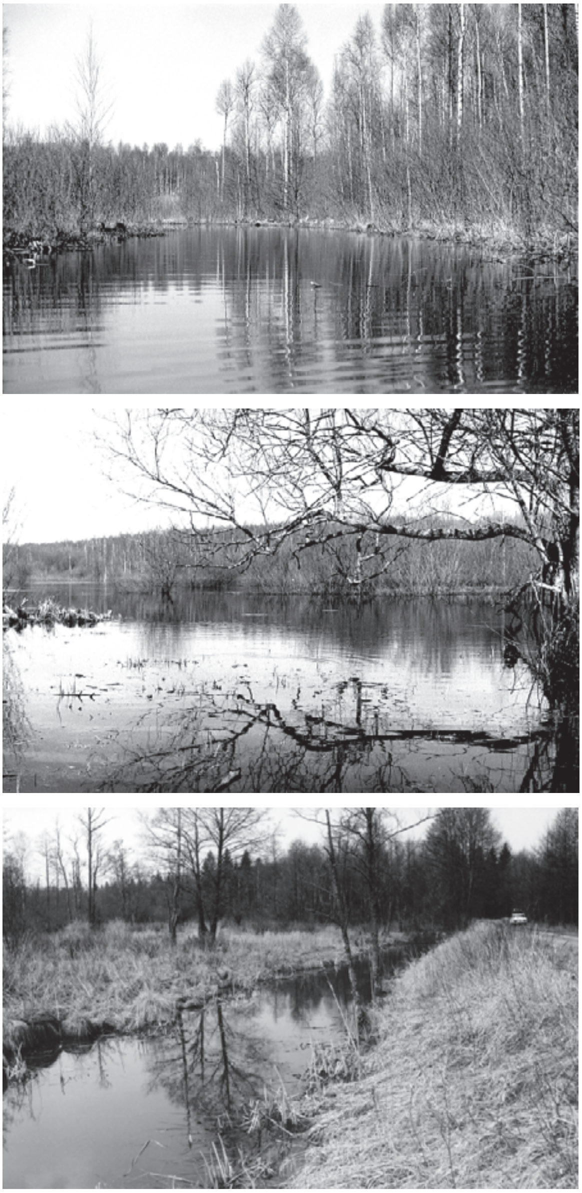


Fig. 9. Breeding sites of *Bufo bufo* at (A) Buzyanka, (B) Berezina River delta, and (C) Volka River.

Embryonic development depends on water temperature and may take 4–15 days. Tadpoles have a dark, almost black color with a transparent tail fin. Their length does not exceed 9–10 mm. Formation of large tadpoles aggregations in the riparian zones is typical. Algae, macrophytes, and detritus prevail in the diet of the larvae.

Body lengths of metamorphs ranges from 11–14 mm. Densities of metamorphs in places of mass emergence near wetlands may reach 55 specimens/m^2. Small invertebrates (e.g., Collembola, Staphylinidae) prevail in the diet in the terrestrial phase of the life cycle. The first two weeks after metamorphosis, up to 50% of the mass of the stomach contents consists of indigestible plant pieces and sand. Apparently, these objects are captured together with food.

In the summer, the Common Toad inhabits open: floodplain meadows, raised bogs, and deciduous and mixed forests (Fig. 11). It is common in cultivated landscapes (e.g., gardens, parks, kitchen gardens, fields, meliorative systems of polder type, villages and urban settlements. The average population density in summer is 5–15 specimens/ha. The greatest numbers are reached in humid and dry mossy spruce stands (to 416.7 specimens/ha). Formicidae (61.5%), Carabidae (11.2%) and Curculionidae (8.3%) prevail in the diet of adults in land ecosystems. We have found to 507 prey items (mean 37.1±4.2) in all stomachs of Common Toads. This species does not feed during mating season.

It enters the hibernacula a little later than most other amphibians at the end of September to the beginning of November. It survives the cold season in burrows in the soil, heaps

Fig. 10. Summer habitat of *Bufo bufo* in Chapun.

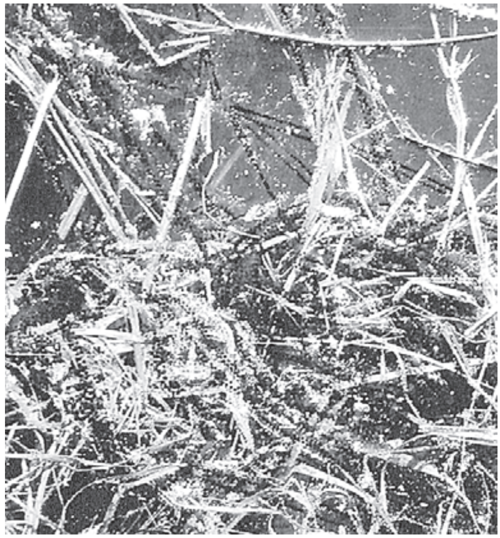


Fig. 11. A clutch of *Bufo bufo*.

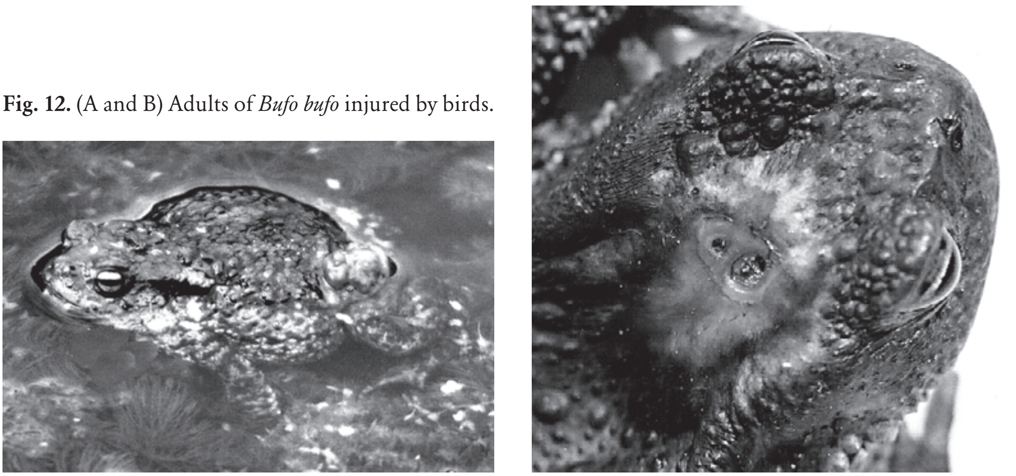


Fig. 12. (A and B) Adults of *Bufo bufo* injured by birds.

of brush, and under fallen trees. In the spring there are mass migrations of the Common Toad to the spawning sites.

Young toads often are prey of adult toads and frogs (Pikulik, 1985). Sometimes the Common Toads are eaten by the Grass Snake (*Natrix natrix*) that is specialized on amphibians (Drobenkov, 1995). Toads also are eaten by polecats, otters, and American and European minks. The latter eat only the belly part of toads because of the numerous toxic glands on the back. Quite often this species is eaten by some birds: *Buteo buteo*, *Aquila pomarina*, *Athene noctua*, *Strix aluco* (Fig. 12). A specific antipredator behavior is known in the Common Toad. In a dangerous situation, the toad rises on the hind and forelegs, inflates the lungs, turns the head toward the predator, shakes, and sometimes makes small attacks.

The main causes of population declines in the Common Toad are land drainage, eutrophication of water, cutting of forests, chemical pollution of environment, and death on motorways.

Green Toad, *Bufo viridis* Laurenti, 1768

Color Plate 6.

The Green Toad inhabits a vast territory from northeastern Africa through Europe to Siberia and Central Asia. The northern limit of its range generally coincides with the northern limit of the mixed forest subzone (Kuzmin, 1999). This species is distributed throughout Belarus, but its population numbers are not high (Fig. 13).

According to the modern taxonomic ideas, the Green Toad is the central member of the *B. viridis* complex involving diploid and polyploid species which can form hybrids.

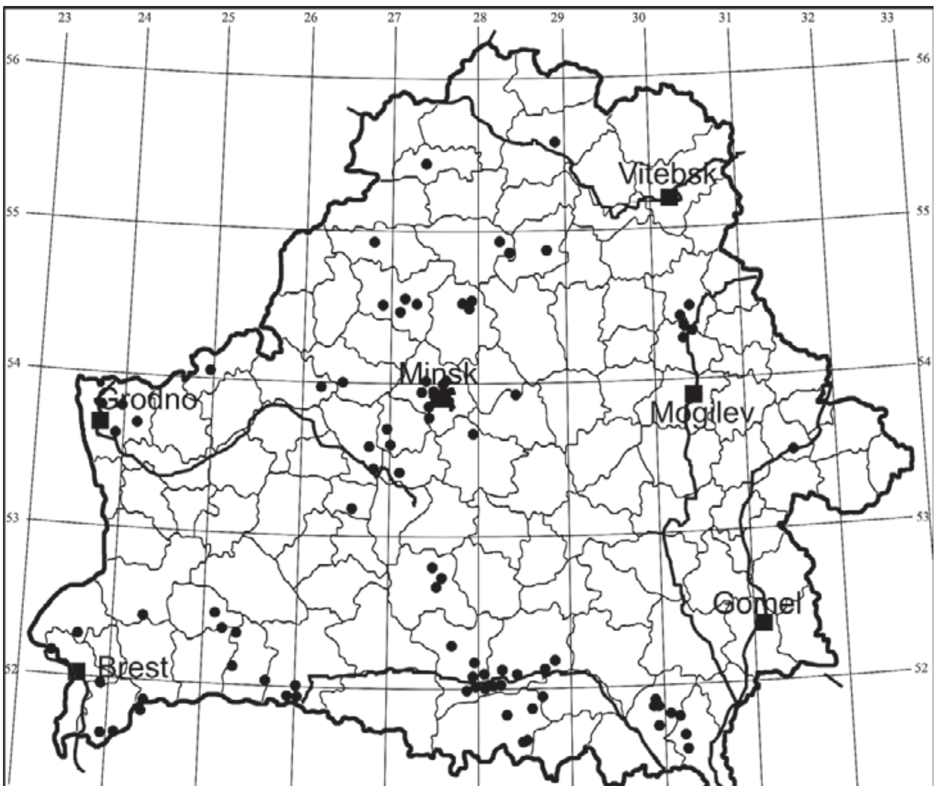


Fig. 13. Distribution of *Bufo viridis* in Belarus.

Within the former USSR,3 subspecies were recognized (Kuzmin, 1999). The nominative subspecies *B. viridis viridis* Laurenti, 1768 occurs in Belarus. The taxonomy of the complex of Green Toads and infraspecific systematics of *B. viridis* need further study.

From the point of view of morphology and ecology, the Green Toad is one of the best studied members of the local fauna (Tables 7 and 8). Maximum body length of individuals from Belarus is 98 mm, mass 73.2 g.

The dorsal skin of the Green Toad has with large blotches and colored in light-grey or greenish. Other dark spots are edged by narrow black borders. There are red dots inside and between the spots. The back pattern is so variable that it is practically impossible to find two identical specimens. Individuals (more often males) with a light mid-dorsal stripe, typical for the Natterjack Toad, occur commonly. The belly and the throat are white, dirty-white or yellowish with dark spots or rarely without them. Subarticular tubercles are singles. There is a longitudinal dermal fold on the interior side of tarsus. Males in the breeding season have with black or brownish-black nuptial pads on the 1st, 2nd and sometimes the 3rd fingers.

The Green Toad is one of the most thermophilic species of amphibians with a very long breeding season. In southern Belarus, spawning usually starts on 10–15April and 10–15 days later in the north. The peak of reproduction in different parts of the Republic falls on the 1st–2nd week of May. However, amplectant toads are found until the end of June. Reproduction

Table 7. Size and measurements of *Bufo viridis* from the territory of Belarus (n=686).

Characters	Males (n=439)		Females (n=247)	
	min – max	M ± m	min – max	M ± m
L	3.63 – 9.49	6.69 ± 0.031	4.4 – 9.8	6.39 ± 0.06
L.c	1.3 – 2.48	1.83 ± 0.007	1.22 – 2.49	1.71 ± 0.014
Lt.c	1.69 – 3.29	2.23 ± 0.011	1.52 – 3.39	2.12 ± 0.021
D.r.o	0.52 – 1.23	0.78 ± 0.006	0.47 – 1.2	0.75 ± 0.009
Sp.c.r	0.44 – 1	0.77 ± 0.004	0.4 – 1.09	0.74 ± 0.006
D.n.o	0.29 – 0.89	0.48 ± 0.004	0.3 – 0.92	0.48 ± 0.007
L.o	0.45 – 0.86	0.62 ± 0.003	0.25 – 0.88	0.58 ± 0.006
Lt.p	0.4 – 0.95	0.63 ± 0.006	0.32 – 1.15	0.62 ± 0.009
Spp	0.37 – 0.89	0.6 ± 0.004	0.39 – 1.12	0.59 ± 0.007
Sp.n	0.32 – 0.6	0.43 ± 0.003	0.3 – 0.67	0.42 ± 0.004
Lt.im	0.17 – 0.62	0.32 ± 0.003	0.14 – 0.5	0.3 ± 0.005
F	1.42 – 3.28	2.44 ± 0.014	1.48 – 3.04	2.22 ± 0.022
T	1.33 – 3.56	2.53 ± 0.013	1.57 – 3.3	2.29 ± 0.021
D.p	0.25 – 0.8	0.54 ± 0.004	0.32 – 0.76	0.49 ± 0.005
C.inth	0.12 – 0.35	0.2 ± 0.002	0.1 – 0.3	0.19 ± 0.002
C.intl	0.19 – 0.53	0.34 ± 0.003	0.2 – 0.59	0.33 ± 0.004
L.gp	0.27 – 1.87	1.43 ± 0.011	0.33 – 1.72	1.32 ± 0.017
L.agp	0.38 – 0.92	0.61 ± 0.007	0.37 – 0.97	0.58 ± 0.009
M	6.67 – 0.6	27.81 ± 0.458	10.1 – 73.2	25.76 ± 0.875
L.c.ext	0.13 – 0.39	0.25 ± 0.003	0.1 – 0.9	0.24 ± 0.006

Table 8. Body proportions of *Bufo viridis* from the territory of Belarus (n=686).

Indices	Males (n=439) M ± m	Females (n=247) M ± m
2T/C.intl	14.68 ± 0.141	13.78 ± 0.214
2T/L	0.76 ± 0.005	0.72 ± 0.009
C.intl/C.inth	1.72 ± 0.02	1.78 ± 0.033
D.p/C.intl	1.56 ± 0.018	1.48 ± 0.025
D.r.o/D.n.o	1.62 ± 0.019	1.54 ± 0.029
D.r.o/L.o	1.26 ± 0.012	1.29 ± 0.02
F/T	0.97 ± 0.007	0.97 ± 0.013
K	0.09	0.1
L/F	2.74 ± 0.02	2.88 ± 0.039
L/F+T	1.35 ± 0.045	1.42 ± 0.066
L/L.c	3.65 ± 0.022	3.73 ± 0.046
L/T	2.64 ± 0.018	2.79 ± 0.037
L.c/D.r.o	2.36 ± 0.021	2.3 ± 0.034
L.c/Lt.c	0.82 ± 0.005	0.81 ± 0.01
L.gp/L.agp	2.33 ± 0.031	2.29 ± 0.046
L-L.c/Lc	5.69 ± 0.136	5.39 ± 0.266
Lt.c/L	0.33 ± 0.002	0.33 ± 0.004
Lt.c/Sp.c.r	2.91 ± 0.02	2.88 ± 0.037
Lt.c/Sp.p	3.71 ± 0.028	3.62 ± 0.057
Lt.im/L.o	0.52 ± 0.005	0.51 ± 0.01
Lt.p/Sp.p	1.05 ± 0.012	1.06 ± 0.02
Sp.c.r/D.r.o	0.99 ± 0.009	0.99 ± 0.015
Sp.c.r/Sp.n	1.76 ± 0.014	1.75 ± 0.023
Sp.c.r/Sp.p	1.27 ± 0.01	1.26 ± 0.019
Sp.p/Sp.n	1.39 ± 0.012	1.4 ± 0.022
T/C.intl	7.34 ± 0.071	6.89 ± 0.107

occurs at water temperatures no lower than 11–12°C. The toad breeds in various water bodies but more often in shallow waters and well-warmed water bodies: temporary puddles, ponds, floodplain meadows, sand pits and fire basins filled with water, former river beds, fishery ponds and water storage reservoirs (Fig. 14). This species prefers shallow (from 0.15–1 m, on the average 0.52±0.082 m), poorly overgrown and open basins with still water.

Green Toads often breed in the same pools as syntopic Natterjack Toads. In such situations, mixed pairs of these species in amplexus occur quite often, and this may create conditions for their natural hybridization. Amplexus is axillary.

Eggs are deposited in long (to 3 m) cords and the spawn is arranged in 1–2 series. It is laid on the bottom of pool or on aquatic vegetation. Maximum fecundity in Belarus may reach 11,643 eggs. Egg diameter is 1.0–1.5 mm. Embryonic development at water temperatures of 18–24°C takes from 3–7 days.

The calling period of the Green Toad, that attracts mature individuals of both sexes to the pool, last until the middle of summer. Males have vocal sacs. Their voices represent a

Fig. 14. Breeding habitat of *Bufo viridis.*

quiet, melodious trill like that of a cricket. About 44% of the males in a pool vocalize. The water temperature has a noticeable effect on the activity of mating choruses. Its maximum occurs at 22–25°C, and at lower than 6°C, male vocalization stops.

This species does not form large breeding aggregations, and no more than 20–25 females rarely occur in one water body. The average density of breeding groups is 4–5 specimens/10 m^2 of water surface or a maximum of 1–3 specimens/m^2. Male:female ratios during spawning vary widely from 1:0.01 to 1:4. Some individuals spawn twice in one season in urbanized landscapes in the center of Minsk City.

The Green Toad tadpoles have olive-grey coloration. They often form aggregations similar to those in the Common Toad (Fig. 15). Tadpole length is 26–50 mm. Metamorphosis occurs at the end of June– beginning of July. Metamorphs 10–15 mm length.

Green Toad is a synanthropic species that is strongly attracted to ecosystems modified by human economic activity. It is resistant to dry conditions and inhabits a wide range of

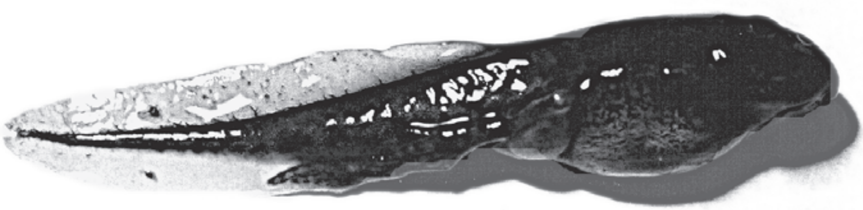


Fig. 15. Larva of *Bufo viridis.*

habitats. The main habitats are open landscapes, agricultural fields, reclaimed bogs, upland and bottomland meadows and settlements. The population density in settlements is usually considerably higher than that in natural ecosystems and can reach 2500 specimens/ha. In villages and cities under street lamps that attract invertebrates, Green Toads often form small aggregations of 5–7 to 20 specimens with a local density of 12 specimens/m^2.

Beetles (Carabidae, 37.5%) and ants (Formicidae, 34.8%) represent the main food of the Green Toad. Cannibalism in this species (37.9%) was noted near Minsk. The number of preys in one stomach can reach 361 specimens (22.2±2.2).

Hibernation starts at the end of September to the beginning of October, but even in the last days of activity Green Toads continue to feed. The stomach-fill index was 0.8±0.002%, with a maximum of 2.4%. The Green Toad hibernate in mouse holes, bank vaults, under stones, in pits, cellars, and under frames of wooden houses and also digs itself into soft soil.

Natural enemies of this species are green frogs and Grass Snakes (*Natrix natrix*) (Drobenkov, 1995).

As noted above, there is a clearly expressed tendency to synanthropization in the Green Toad in contrast to the majority of other amphibians. However, even for this ecologically plastic species, some kinds of anthropogenic activity may have negative effect and cause population declines. The main negative factors are destruction of breeding wetlands, chemical pollution of environment and intensive traffic movement.

Natterjack Toad, *Bufo calamita* Laurenti, 1768

Color Plate 7.

The Natterjack Toad inhabits Western Europe northwards to southern Sweden and Britain and south to northern Italy, Austria and the Czech Republic (Kuzmin, 1999). In Belarus, the eastern range margin extends approximately along a line connecting the cities of Glubokoe – Lepel – Bobruisk – Mozyr (Pikulik, 1985). It is a rare species that is distributed very irregularly (Fig. 16) and is included in the Red Data Book.

The Natterjack Toad is close to the Green Toads (complex *B. viridis*), whose taxonomy requires further study (Kuzmin, 1999). Subspecies are not recognized.

The Natterjack Toad is a small amphibian with a maximum body length in Belarus that does not exceed 72.7 mm and a mass of 34.5 g (Table 9). Other morphometric characters are in Tables 9 and 10. Subarticular tubercles on toes are paired, but occasionally the tubercles on the 2nd toe may be not paired. The tip of 4th finger does not reach the 1st articulation of the 3rd finger. The interior edge of the tarsus has a longitudinal dermal fold. Parotid glands are large. Coloration of the back is greyish-olive or greenish with more dark spots and small red dots. There is a definite narrow (0.7–1.3 mm), continuous or discontinuous mid-dorsal stripe of yellow or light-yellow. This strip may have 1–9 interruptions between the tip of snout

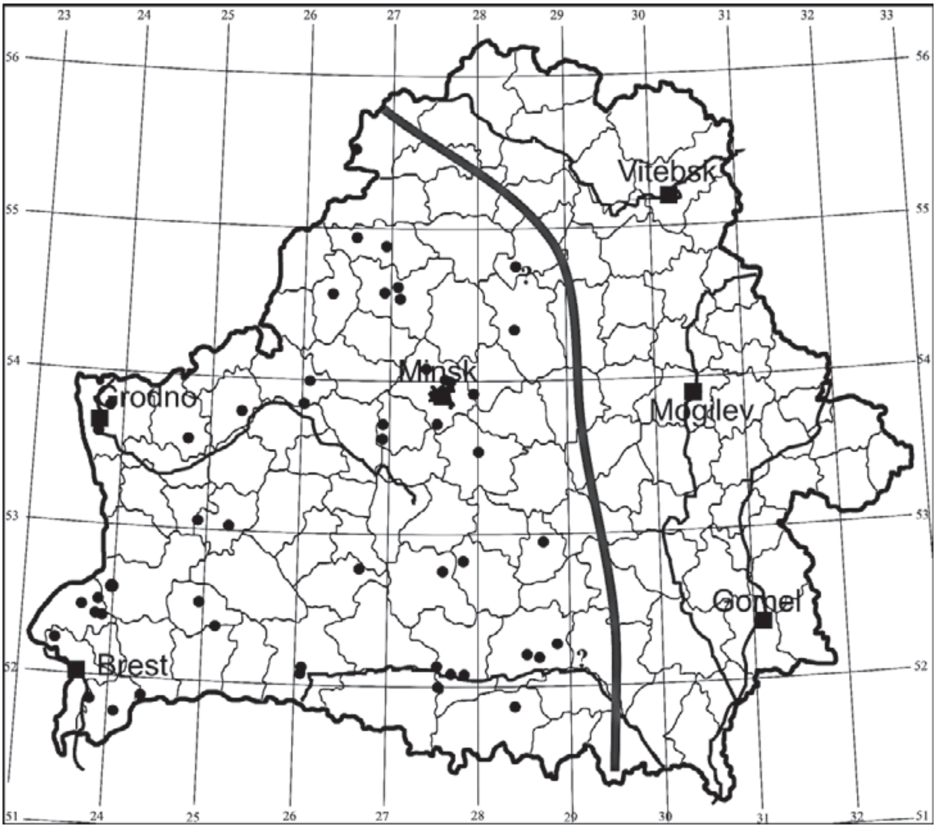


Fig. 16. Distribution of *Bufo calamita* in Belarus.

and the coccyx. The belly is white, dirty-white or yellowish with small dark spots. Males during the breeding season have black or brownish-black nuptial pads on the 1st, 2nd and sometimes the 3rd finger (Fig. 17).

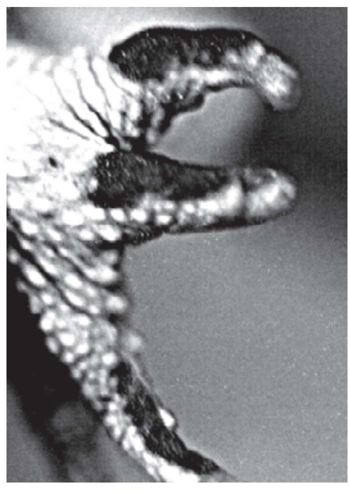


Fig. 17. Nuptial pads of *Bufo calamita* (Maloritskii District, Ryta River).

The Natterjack Toad is one of the most thermophilous species of amphibians with a very long breeding season. After hibernation it appears in water bodies at the end of April. The first mating calls of males in the central part of Belarus are noted on 21 April at an air temperature of 20°C and a water temperature of 14°C. The peak breeding usually occurs in the second half of May, but some individuals deposit eggs to the end of June and the first part of July.

The average density of vocalizing males is 2–3 specimens/10 m^2. The number of breeding aggregations is rarely more than 15–20 toads per wetland. The mating

Table 9. Size and measurements of *Bufo calamita* from the territory of Belarus (n=153).

Characters	Males (n=146)		Females (n=7)	
	min – max	M ± m	min – max	M ± m
L	4.05 – 7.13	5.69 ± 0.056	5.7 – 7.27	6.47 ± 0.244
L.c	1.12 – 1.93	1.59 ± 0.014	1.41 – 2.21	1.76 ± 0.102
Lt.c	1.22 – 2.29	1.83 ± 0.017	1.91 – 2.3	2.09 ± 0.058
D.r.o	0.39 – 0.96	0.59 ± 0.009	0.5 – 0.9	0.64 ± 0.058
Sp.c.r	0.45 – 0.78	0.62 ± 0.005	0.62 – 0.79	0.7 ± 0.021
D.n.o	0.2 – 0.53	0.33 ± 0.006	0.3 – 0.53	0.4 ± 0.036
L.o	0.32 – 0.73	0.56 ± 0.005	0.59 – 0.71	0.63 ± 0.014
Lt.p	0.37 – 0.92	0.53 ± 0.007	0.5 – 0.83	0.64 ± 0.051
Sp.p	0.36 – 0.61	0.47 ± 0.005	0.44 – 0.63	0.54 ± 0.027
Sp.n	0.28 – 0.52	0.37 ± 0.004	0.37 – 0.52	0.44 ± 0.022
Lt.im	0.11 – 0.42	0.25 ± 0.006	0.16 – 0.35	0.26 ± 0.028
F	1.12 – 2.58	1.86 ± 0.023	1.56 – 2.45	2.01 ± 0.122
T	1.22 – 2.59	1.93 ± 0.02	1.71 – 2.28	2.06 ± 0.094
D.p	0.33 – 0.73	0.55 ± 0.007	0.47 – 0.7	0.59 ± 0.036
C.inth	0.09 – 0.23	0.14 ± 0.002	0.12 – 0.2	0.17 ± 0.009
C.intl	0.16 – 0.37	0.26 ± 0.004	0.2 – 0.38	0.29 ± 0.025
L.gp	0.52 – 1.28	0.88 ± 0.012	0.52 – 0.98	0.8 ± 0.089
L.agp	0.32 – 1.11	0.5 ± 0.007	0.43 – 1.17	0.64 ± 0.135
M	9.23 – 7.45	18.17 ± 0.75	24.84 – 3.45	35.49 ± 4.52
L.c.ext	0.14 – 0.39	0.23 ± 0.004	0.19 – 0.36	0.27 ± 0.03

call is very loud and in the open landscapes it is audible for at least 2.0–2.5 km. The call is a rather acute trill.

Eggs are laid in long cords usually on the bottom. One clutch contains up to 2300 eggs. The diameter of egg is 1.1–1.5 mm. Larvae form aggregations (Fig. 18). Tadpoles in later stages of development have a typical middorsal stripe (Fig. 19). Lengths of metamorphs are 12–18 mm, and densities in riparian zones can reach 32–55 specimens/m^2. At first the metamorphs stay near water but eventually disperse 1.0–1.3 km.

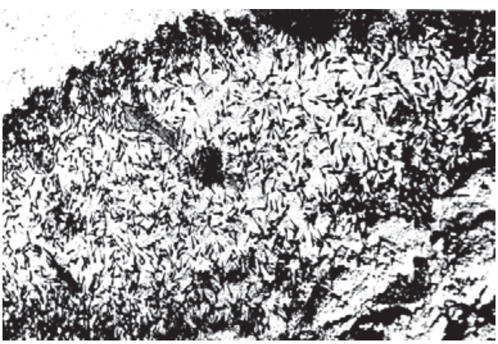


Fig. 18. Aggregation of *Bufo calamita* tadpoles.

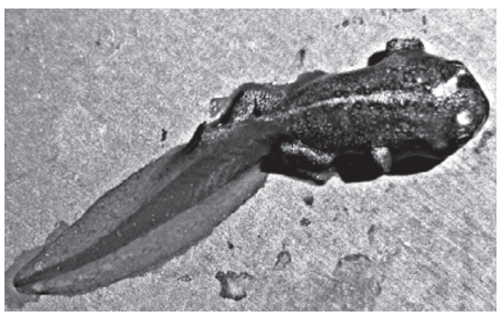


Fig. 19. Metamorphosing tadpole of *Bufo calamita* (Zasulie, Vileika).

Table 10. Body proportions of *Bufo calamita* from the territory of Belarus (n=153).

Indices	Males (n=146) M ± m	Females (n=7) M ± m
2T/C.intl	15.01 ± 0.266	14.4 ± 1.424
2T/L	0.68 ± 0.01	0.64 ± 0.038
C.intl/C.inth	1.79 ± 0.039	1.69 ± 0.176
D.p/C.intl	2.15 ± 0.041	2.07 ± 0.22
D.r.o/D.n.o	1.77 ± 0.041	1.61 ± 0.207
D.r.o/L.o	1.05 ± 0.019	1.01 ± 0.095
F/T	0.96 ± 0.016	0.98 ± 0.074
K	0.1 ± 0	0.13
L/F	3.06 ± 0.048	3.22 ± 0.23
L/F+T	1.5 ± 0.084	1.59 ± 0.192
L/Lc	3.59 ± 0.047	3.68 ± 0.256
L/T	2.95 ± 0.043	3.15 ± 0.187
L.c/D.r.o	2.69 ± 0.047	2.75 ± 0.297
L.c/Lt.c	0.86 ± 0.011	0.84 ± 0.054
L.gp/L.agp	1.77 ± 0.035	1.26 ± 0.303
L-L.c/L.c	4.69 ± 0.239	5.47 ± 1.083
Lt.c/L	0.32 ± 0.004	0.32 ± 0.015
Lt.c/Sp.c.r	2.97 ± 0.038	3.01 ± 0.125
Lt.c/Sp.p	3.87 ± 0.052	3.88 ± 0.22
L.tim/L.o	0.45 ± 0.011	0.41 ± 0.045
Lt.p/Sp.p	1.13 ± 0.018	1.19 ± 0.111
Sp.c.r/D.r.o	1.05 ± 0.018	1.09 ± 0.104
Sp.c.r/Sp.n	1.65 ± 0.023	1.58 ± 0.093
Sp.c.r/Sp.p	1.3 ± 0.017	1.29 ± 0.075
Sp.p/Sp.n	1.26 ± 0.018	1.23 ± 0.086
T/C.intl	7.51 ± 0.133	7.2 ± 0.712

Breeding pools of the Natterjack Toad are usually rather shallow (0.1–0.3 m) and warm during the day, and as a rule, vegetation is lacking. These are mainly reservoirs of anthropogenic origin such as sandpits filled with water, fire-fighting basins, dumps, modified channels, and temporary puddles on agricultural fields. Rather often (ca. 40%) this species and the Green Toad occur in the same pools, but other amphibians seldom occur there.

In the summer, the Natterjack Toad inhabits mainly open cultivated landscapes such as fields, meadows, reclaimed lands, and waste grounds. It prefers light sandy soils. Population densities in each season in a typical habitat are usually not high and usually include 25–60, occasionally up to 200 specimens/ha. The highest activity occurs after rains that fall after a long period of a dry weather. The toad digs holes in light soils where it seeks shelter in the hot time of the day. However, it regularly changes refugia. Insects from the families Chrysomelidae (28.4%), Formicidae (18.2%) and Curculionidae (16.7%) prevail in the diet of the Natterjack Toad. Feeding does not cease in the breeding season.

The species hibernates from the end of September by burying itself in the soil (to 0.7 m) or in piles of stones used during the summer.

A noticeable tendency for synanthropization is clear. Some forms of economic activity, for example building of settlements, cattle breeding farms, motorways and modified systems, promote increases of the toad population size. Sand pits, ditches and pits formed at building sites and filled with water are breeding habitats of the Natterjack Toad. Adjoining agricultural lands are optimal summer habitats. The dynamics of the population number in Belarus depends in a large part, apparently, on periodic drying of shallow breeding wetlands. Drought results in loss of all spawn and tadpoles.

Family HYLIDAE Gray, 1825

Genus *Hyla* Laurenti, 1768

Common Tree Frog *Hyla arborea* (Linnaeus, 1758)

Color Plate 8.

The geographical distribution of the Common Tree Frog covers western, central and eastern Europe, as well as the Caucusian region (Kuzmin, 1999). In Belarus the geographical range border extends approximately along a line connecting the cities of Oshmyany – Uzda – Slutsk – Svetlogorsk – Gomel (Pikulik, 1985; Fig. 20).

Four subspecies are recognized. Within Belarus the nominate subspecies *H. arborea arborea* (Linnaeus, 1758) is found.

This is a small amphibian. Body lengths do not exceed 44.5 mm (Table 11). The upper surface of the body is usually light-green. However, depending on the color of the substrate

Table 11. Size and body proportions of *Hyla arborea* from the territory of Belarus (n=121).

Characters	M ± m	min – max
L	36.2 ± 0.7	20.0 – 44.5
L.c	13.1 ± 0.3	8.3 – 17.5
Lt.c	12.8 ± 0.3	8.5 – 15.2
L.o	3.5 ± 0.1	2.7 – 4.4
F	18.5 ± 0.4	9.0 – 24.2
T	17.2 ± 0.4	8.0 – 21.4
L–L.c/L.c	1.7 ± 0.04	1.2 – 2.6
L/L.c	2.7 ± 0.04	2.2 – 3.6
L/T	2.1 ± 0.01	1.8 – 2.5
F/T	1.1 ± 0.01	0.9 – 1.2
m	4.6 ± 0.3	0.8 – 7.5

Fig. 20. Distribution of *Hyla arborea* in Belarus.

and the environmental temperature, the color may become dark-green, brownish, completely black or even grey with a metallic tint. The venter is white or occasionally yellowish. The back skin is smooth and the belly skin is granular. On the border of the belly and the back part of the groin region there is a narrow black band (so-called inguinal loop). There are disks on the tips of the digits that excrete sticky material that permits the frog to climb quite well on vertical surfaces. The pupil is horizontally elliptical.

The majority of morphometric characters do not show sexual dimorphism. Males differ by presence of a ventral vocal sac and by being a little larger.

The Common Tree Frog is one of the most thermophilous amphibians of Belarus. Hibernation ends at the beginning of April at an air temperature above 6–8°C. However, mating calls of males appear 7–10 days later at a temperature above 10°C. Spawning takes place from the end of April to the end of June. However, its peak falls usually during the middle to second half of May. Air temperatures at reproduction are within the range of 12– 23°C.

The Tree Frog breeds in warm wetlands with a light flow or in ditches with depths of 0.4–0.5 m. Local aggregations of the Tree Frog consist of 15–20 adult males and several

females. Their composition varies permanently. At some especially favorable sites (e.g., shallow fishery ponds, moors, and fen alder forests) several hundred individuals sometimes concentrate and make great choruses.

The mean density in breeding groups is 3–5 individuals of both sexes/10–15 m^2 of surface area. The mating call is an acute rhythmic sound similar to loud "te-te-te." It can be imitated by some people and this provokes answers from males. During summer mating choruses start at twilight (2100–2130), but in spring they quite often can be heard in the afternoon, especially in warm cloudy weather. Vocalization of the Tree Frog lasts to the middle or end of July, sometimes a little later.

Social organization of breeding groups, which is manifested in a strict hierarchy of breeding males, is typical for the Tree Frog. Together with territorial males, emitting vocalizations and occupying individual areas in the central part of a basin, there are less obvious satellite males that do not call but do participate in amplexus. The proportion of females in breeding pools is always much lower than that of males. Male:female ratios vary from 1:15–1:5, though the real composition of a population is characterized by approximately equal number of individuals of both sexes. Such unbalance is explained by the fact that females stay in the water no more than 1–2 days and leave after spawning.

During amplexus, the male holds a female in the axillary region (axillary amplexus). Clutches are laid as spheres or lumps and are situated in the water by one or in small groups of 2–6. The clutch consists of 375–1725 eggs (mean 1024.2±233.9). Embryonic development at a temperature of 16–19°C takes 1.5–2.0 weeks. Tadpoles are golden-greenish with a metallic tint on the belly. Tadpoles have high fins (pelagic tadpole type) that allow them to spend much time in the water column (Fig. 21). Larval development takes an average of 2.0–2.5 months Metamorphosis occurs from the end of July to the end of August. Lengths of metamorphs are 15–18 mm. At the end of the summer young Tree Frogs occur near wetlands on riparian shrubs and herbaceous vegetation.

In Belarus the species inhabits deciduous (oak woods, alder woods, birch forests) and mixed forests, lowland meadows overgrown with shrubs, low and transitional moors, parks, and gardens. The most typical localities are fen alder forests and wood sedge fens. Population densities on land can reach 40–125 specimens/ha. In the summer, during the non-reproductive season, this frog leads an arboreal life in shrubs where it is active mainly in the evening and night time. This species more than any

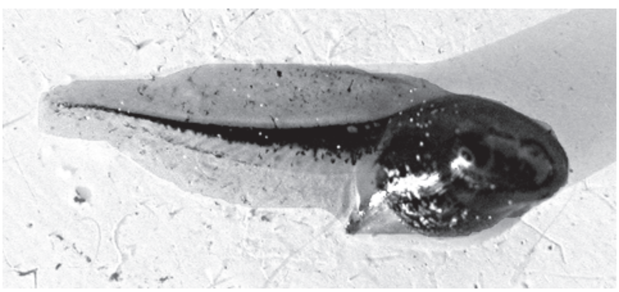


Fig. 21. *Hyla arborea* tadpole (Petrokovskii District).

other amphibians is resistant to drying. In a dry atmosphere the frog loses up to 30% of its mass without any harm, and rapidly rehydrates by visiting water or wet soil.

The Tree Frog hibernates not far from wetlands in forest habitats in leaf debris, under pieces of tree bark laying on the ground, in tree butts, and in piles of brush.

The diet includes various invertebrates: Diptera (13.9%), Arachnida (12.4%), Chrysomelidae (9.0%), Hemiptera (7.5%), Formicidae (7.5%), Elateridae (7.0%), and Curculionidae (5.5%). Flying insects play a noticeable role in the feeding of this species, and feeding does not stop during the breeding season. Cannibalism is known for tadpoles, and they quite often eat spawn of their own species. Storks, herons, foxes, raccoon dogs and badgers occasionally eat Tree Frogs. In a few cases it was found in stomachs of the Grass Snake (*Natrix natrix*), which specializes on consumption of amphibians (Drobenkov, 1995).

The Common Tree Frog successfully adapt to the modified conditions of anthropogenic landscapes. It is common in settlements, in recreation areas, and in drainage systems with remains of suitable aquatic and forest habitats. Together with the Fire-Bellied Toad, it quite often inhabits purification ponds and pools in cattle breeding complexes which are supersaturated with organic matter. Recently Tree Frogs were observed in urbanized territories even more often than in adjacent natural ecosystems. In the central part of the Republic, on the limit of its distribution, populations of this species are fragmented, and their number fluctuate considerably by years. However, in Polesie this is a common species of the local fauna. The main forms of anthropogenic effect that lead to population declines are destruction of breeding basins, chemical pollution of basins by industrial wastes, insecticides and mineral fertilizers, and capturing for keeping in terraria. The mortality rate on highways is low (Ryzhevich, 1989).

Family RANIDAE Gray, 1825

Genus *Rana* Linnaeus, 1758

Common Frog, *Rana temporaria* Linnaeus, 1758

Color Plate 9.

The Common Frog is distributed in Europe from the Pyrenees to the Urals and western Siberia. In the northwestern part of the geographic distribution, it reaches to the Barents and White seas. The southern limit of the distribution extends to southern France, Italy, the Balkan Peninsula, central Moldavia and southern Ukraine. In many southern regions (Apennines, Balkan, Crimea and the Caucasus) it is absent (Bannikov et al., 1977; Szczerbak and Szczerban, 1980; Kuzmin, 1999).

The Common Frog is common in Belarus, is often dominant among amphibian species, and is distributed throughout the country (Fig. 22). Only in the central part of the floodplain zone of the Pripyat River in the lower reaches of the Lan and Goryn rivers are there extensive micro-disjunctions or absences. Such situations are correlated with prolonged flood processes which complicates frog migrations from hibernacula to coastal areas used for breeding (Pikulik, 1985).

At present, 4 subspecies are distinguished. The nominate subspecies *R. temporaria temporaria* Linnaeus, 1758 occurs in Belarus.

In morphological and ecological aspects, the Common Frog is one of the most studied representatives of the aboriginal batrachofauna (details of external morphology see below: Chapter 5). Body length does not exceed 100 mm. The body is massive, slightly elongated with a flat head. The inner metatarsal tubercle is rounded and low. Dorsal coloration is brown, grey-brown or reddish-brown. The belly is spotted or marbled.

Common and Moor Frogs are very similar but the striped pattern is typically absent in Common Frogs. A mid-dorsal stripe usually extends from the vent to a chevron-shaped

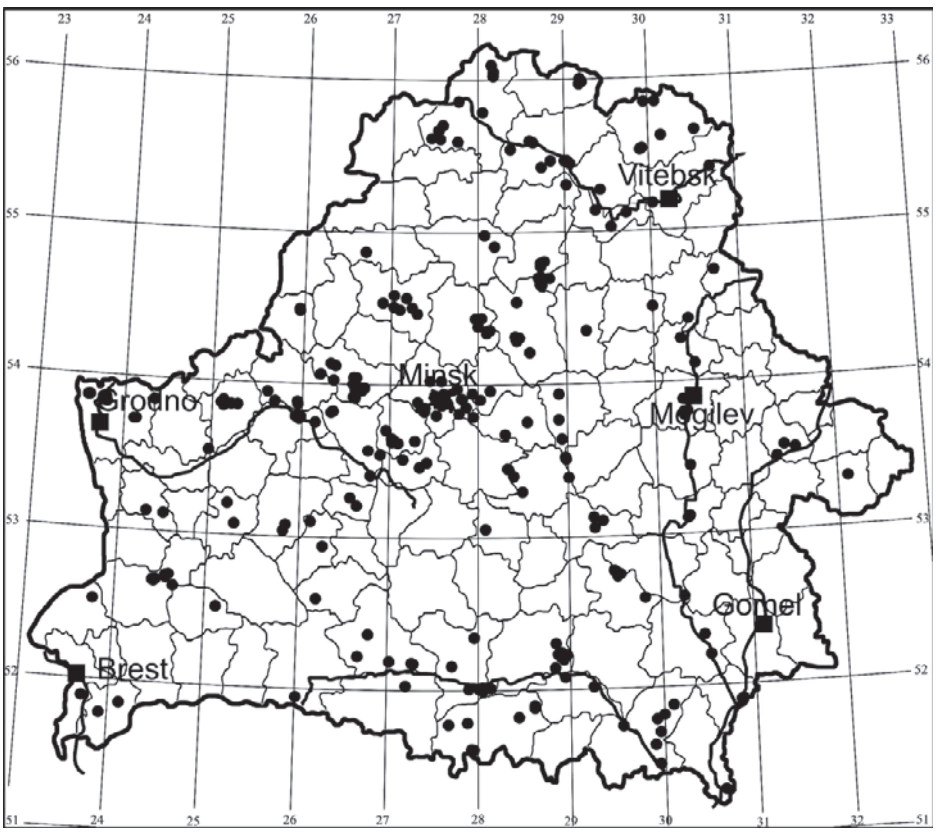


Fig. 22. Distribution of *Rana temporaria* in Belarus.

spot and has a indistinct edge. The shape and degree of the chevron-shaped spot is quite variable. The head pattern is well-developed. The temporal spot is well discernible, although occasionally it is absent. There are 3–4 transverse dark stripes on the shin and thigh.

Throat coloration varies from complete absence of a marbled pattern on a pale background to entirely covered with dense spots. Males have internal vocal sacs, and their throat is blue during the breeding season. A nuptial pad on the 1st finger has four lobes. Variability of morphometric characters of frogs from the region falls within the limits of variations in the species range. Within Belarus there is considerable interpopulational variability based on some characters of external morphology.

After hibernation the Common Frog appears and breeds before other amphibians. The first individuals in the central part of the Republic are observed on the shores of water bodies in 15–20 March at an air temperature of 5–10°C. The breeding season in comparison with other species is not long, only 2.0–2.5 weeks. The mass spawning usually occurs in the first half of April at a water temperature 7–11°C. Breeding habitats of Common Frogs that winter in flowing rivers, channels, brooks and springs are usually located near the hibernacula. The distance of spring migrations is insignificant, from 10–20 to 100–150 m.

The mating call is a quiet, hoarse rumbling. Amplexus is axillary. Quite often males clasp Moor and Green frogs, Common Toads, pieces of bark, bottles and other objects. Spawning occurs in shallow water (15–30 cm). Several dozen adults are concentrated in a water body, and in the most favorable of them may include 150–200 or more individuals. Population density in breeding aggregations can reach 5–9 specimens/m^2 of water surface. Clutches of the Common Frog are usually deposited in a restricted area of pool. Their density can reach 40–50/m^2. Each clutch contains 850– 4100 (more often 1400–1650) eggs. The Common Frog eggs and tadpoles in wetlands that are filled during high waters often die.

The embryonic development at water temperatures of 7–11°C takes 10–12 days. Tadpoles stay near the shore where they often form large aggregations that move synchronously in one direction along a shore line. Tadpoles develop about 2.0–2.5 months and the first metamorphs move onto land usually in the middle to end of June.

In the region of our studies, the Common Frog inhabits a variety of natural and modified wood, meadow, moor and floodplain habitats. However, in comparison with the Moor Frog, this species has higher humidity requirements that, apparently, effect its habitat distribution and diurnal activity. The Common Frog in Belarus occurs mainly in humid woods. The species is distributed unevenly. In gallery alder forests and oak woods the average level of density reaches 550 specimens/ha but on lowland meadows only 120 specimens/ha.

The diet includes different groups of invertebrates, but Gastropoda (25.0%), Homoptera (17.0%), Lepidoptera (15.9%), Aranei (12.4%) and Diptera (7.3%) are common. Depending on the habitat and seasonal activity, the composition of the diet varies considerably. During breeding the frogs do not feed. During larval development it feeds on blue-green algae and diatoms.

Tadpoles are eaten by aquatic invertebrates, fishes, larvae of the majority of other amphibians, Grass Snakes and Common Vipers, waterfowl, storks, gulls and semi-aquatic mammals.

The anthropogenic modification of natural ecosystems produces an ambiguous effect on the populations. At present, the main negative effect is caused, apparently, by destruction or gradual degradation of breeding habitats. As a result of land reclamation and other hydro-engineering measures, which embrace a considerable part of the Republic in many regions, the numbers of this species have decreased drastically. Elsewhere, increases are promoted by the increasing modifications of flowing waters suitable for hibernation and increases of habitat diversity. The Common Frog is rather common in urban landscapes of Belarus in natural ecological channels such as river network and systems of channels and adjacent woodlands. In addition, an important component, except for drying of basins in the breeding season, is caused by other natural factors. During hibernation in small closed basins with low levels of water aeration mass mortality of frogs occurs (60–80% of individuals).

Moor Frog, *Rana arvalis* Nilsson, 1842

Color Plate 10.

The Moor Frog has an extensive geographical range in northeastern France, southern Sweden, Finland, Karelia, the shores of the White Sea, lower reaches of the Pechora, south of Yamal Peninsula and the lower reaches of the Yenisei River in Siberia. The southern limit is near Altai, northern Kazakhstan, the Ural River, the lower reaches of the Volga, as well as Romania, Hungary, and the upper reaches of the Danube and Rhine rivers (Kuzmin, 1999). In Belarus, this species occurs everywhere and is common (Fig. 23).

Two subspecies are recognized: *R. arvalis arvalis* Nilsson, 1842 and *R. arvalis wolterstorffi* Fejervary, 1919 (Kuzmin, 1999). In Belarus, the nominate subspecies *R. arvalis arvalis* occurs.

The body length in the Moor Frog in our studies did not exceed 61.5 mm (details of external morphology see below: Chapter 5). The snout is pointed, and the temporal spot, as a rule, is well-developed and extends from the eye through the tympanic membrane almost to the humerus. The inner metatarsal tubercle is tall and oblate from the sides. The skin on the sides and thighs is smooth but there are knobs on the back. There is a variable glandular chevron-shaped spot on the neck.

Male differs from female by the presence of nuptial pads on the 1st finger, a pair of internal vocal sacs and blue body coloration in the breeding season. About 0.62% of 4000 Moor Frogs studied by us had 6 toes on both hind legs, 0.14% on one hind leg and in one case 7 toes on one hind leg (Pikulik, 1985). The share of individuals with polydactyly was 2.92–3.14% in metamorphs and 1.50–2.42% in adults in some populations.

The dorsal color of the Moor Frog varies from pale-brownish to dark brown. The belly is milk-white with considerable pigmentation. The pattern and coloration of the sides vary

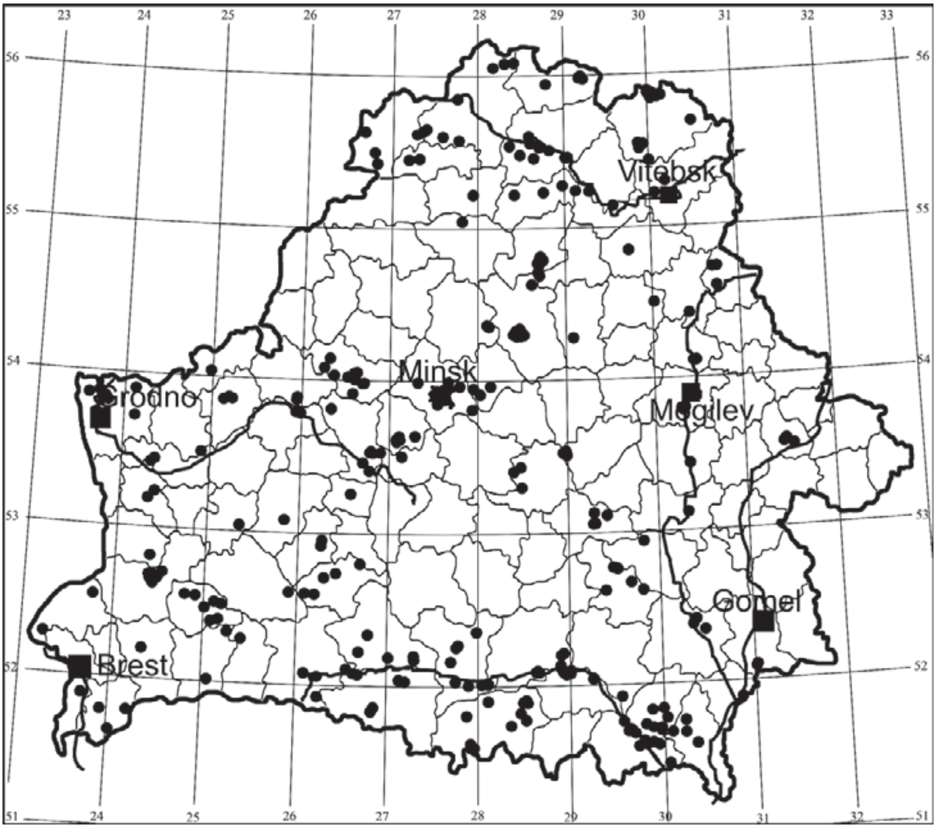


Fig. 23. Distribution of *Rana arvalis* in Belarus.

geographically and among populations. The dark spots vary in size and shape, and the number and shape allows one to distinguish discrete phenotypes.

The breeding season in central Belarus usually falls in the middle of April after the air temperature rises to 10–12°C, in various types of wetlands (Fig. 24). Spawning occurs 3–6 days later then in the Common Frog and almost simultaneously with the Common Toad. Breeding in each water body is quite synchronous and for a majority of population lasts about 5–9 days. However, differences in time and duration of the breeding season in habitats that are reasonably close together but different in microclimate and ecological conditions can differ considerably.

A male mating call represents a quiet monotonic "gurgling" easily recognized from no more than 70–100 m. Amplexus is axillary. Clutches of the Moor Frog are spheres or lumps situated near the shores of wetlands and on shallow water, quite often together with the spawn of the Common Frogs. Several dozen adults are concentrated in each breeding aggregation, and in some optimal habitats with homogeneous conditions there may be 200–300 and more individuals. The population density in breeding habitats in a given

Fig. 24. Breeding wetlands of *Rana arvalis*: (A) Olmany mires, (B) near Minsk.

season can reach 7–9 specimens/m^2 of wetland. Similarly to the Common Frog, the spawn and tadpoles quite often die because of drying wetlands.

The number of eggs per clutch varies from 350–1730. Development of eggs at water temperatures of 14–18°C takes about 12–19 days. The number of tadpoles can be a number of thousand individuals at 150–1050 specimens/m^2. The larval development takes 2.0–2.5 months, and metamorphosis occurs from the end of June into July.

The Moor Frog eurytopic. In Belarus, it occurs in meadows, moors, agricultural lands, forests, gardens, kitchen gardens, parks and settlements and usually is most common among local species. The population density varies considerably among ecosystem (3.1–5422.6 specimens/ha). Population size is determined, first of all, by the presence of suitable breeding pools and hibernacula. The Moor Frog spends the cold season buried in the soil on land. In this connection, in cold but not snowy winters it suffers from low temperatures.

Homoptera (43.2%) notably dominate in the diet after metamorphosis and include considerable numbers of mollusks (Gastropoda, 15.1%), flies (Diptera, 15.1%) and spiders (Aranei, 7.4%). Feeding selectivity seems to be very low. Tadpoles eat green and diatom unicellular algae and detritus. This species is eaten by a great number of predators, such as numerous aquatic beetles, many species of fishes, birds (waterfowl), amphibians, reptiles (snakes) and mammals (mustelids).

Many forms of human economic activities and, first of all, destruction and chemical pollution of breeding wetlands have a negative effect on populations of the Moor Frog. Intensive traffic has a significant negative effect on some populations. In a square meter of some roads and highways (mainly in spring) there may be 2–5 frogs killed by cars. At the same time, the Moor Frog is most adapted to urbanization and recreation. It occurs in suburbs of such large cities as Minsk, Grodno, Mogilev, and Brest. Increases in number of this species are promoted by the creation of artificial ponds, water storage basins, and modified channels.

Marsh Frog, *Rana ridibunda* Pallas, 1771

Color Plate 11.

The Marsh Frog is distributed from north Africa, west and central Asia, Caucasus, Crimea, north and central Europe, the European part of Russia (to 60°N), and Kazakhstan (Bannikov et al., 1977, Kuzmin, 1999). In Belarus, it is distributed everywhere, quite often dominating in amphibian complexes of riparian ecosystems (Fig. 25).

Subspecific systematics of the Marsh Frog is poorly known, and it is difficult to identify the taxonomic positions of this species in Belarus. The Marsh Frog is considered to be a complex of 9–10 species (Kuzmin, 1999). Marsh and Pool frogs are the parent forms, from which as a result of hybridization, the Edible Frog appears.

The Marsh Frog is one of the largest amphibians of Belarus. The body length of this species reaches 96.4 mm (Table 12). The body has an elongated shape with an ovate snout. Webs on the forelegs are absent but well developed on the hind legs. If one presses the thighs to the shins and arranges them perpendicularly to the longitudinal body axis, the talocrural joints overlap. The inner metatarsal tubercle is low, their length is 2.11–3.94 times less then that of the 1st toe (Fig. 26).

Fig. 25. Distribution of *Rana ridibunda* in Belarus.

Fig. 26. Inner metatarsal tubercle of *Rana ridibunda*.

Table 12. Size and body proportions of *Rana ridibunda* from the territory of Belarus (n = 120).

Characters	Males		Females	
	M±m	min – max	M±m	min – max
L	59,46 ± 1,881	50,0 – 81,6	55,76 ± 4,131	37,1 – 84,5
D.r.o	10.58 ± 1.193	8.9 – 13.0	9.52 ± 2.684	5.60 – 14.80
L.o	5.43 ± 0.799	4.3 – 7.0	4.92 ± 1.36	3.30 – 7.50
L.tym	4.36 ± 0.581	3.2 – 5.6	3.84 ± 1.050	2.30 – 6.00
Sp.oc	9.20 ± 0.901	7.7 – 11.10	8.40 ± 2.094	5.80 – 12.20
F	32.86 ± 4.616	7.8 – 42.8	28.27 ± 9.47	16.90 –51.20
T	34.34 ± 5.066	28.5 – 44.8	30.79 ± 9.829	19.30 – 50.60
C.s	19.20 ± 2.542	16.1 – 23.8	17.17 ± 5.204	11.20 –28.30
P	38.06 ± 4.404	32.1 – 46.1	33.39 ± 9.775	21.00 – 51.50
D.p	9.46 ± 1.996	7.6 – 12.7	8.39 ± 2.702	5.00 – 13.40
C.int	3.29 ± 0.496	2.4 – 4.5	2.91 ± 0.838	1.80 – 5.10
L/L.c	3.01 ± 0.191	2.33 – 3.22	3.11 ± 0.158	2.80 – 3.49
L.c/L.t.c	0.95 ± 0.053	0.86 – 1.04	0.91 ± 0.043	0.79 – 0.96
L.c/L.o	4.09 ± 0.409	3.40 – 4.77	3.96 ± 0.324	3.28 – 4.56
L.o/L.tym	1.25 ± 0.151	1.00 – 1.54	1.29 ± 0.153	1.03 – 1.61
L.c/D.r.o	2.08 ± 0.060	1.95– 2.20	2.05 ± 0.129	1.85 – 2.45
D.r.o/L.o	1.97 ± 0.23	1.60 –2.44	1.94 ± 0.196	1.51 –2.33
Sp.o/D.r.o	0.87 ± 0.052	0.75– 0.95	0.89 ± 0.075	0.76 – 1.04
L/T	1.94 ± 0.197	1.46– 2.20	1.98 ± 0.087	1.79 –2.14
F/T	0.96 ± 0.037	0.88– 1.02	0.92 ± 0.047	0.82 – 1.03
L/(F+T)	0.99 ± 0.097	0.74 –1.12	1.04 ± 0.049	0.95 – 1.13
T/C.s	1.79 ± 0.156	1.64– 2.32	1.79 ± 0.069	1.66 – 1.95
L/C.int	20.32 ± 2.31	16.3 – 25.83	20.9 ± 2.31	16.91 –26.72
T/C.int	10.48±0.825	9.25 – 11.96	10.54 ±1.092	9.06 –13.41
D.p/C.int	2.90 ± 0.344	2.11 – 3.50	2.87 ± 0.338	2.45 – 3.94

Males have paired dark-grey or almost black vocal sacs and have nuptial pads on the 1st finger. On each side of the back there are well developed lateral folds typical for the aquatic forms. Dorsal coloration is brown-green with a prevalence of brown, fulvous, green or occasionally olive tints. On the back there are large dark spots that vary in number, size and shape. The majority of individuals (to 90%) have a mid-dorsal pale stripe of different widths and shapes. The belly is grayish-white or grayish-yellow with a marbled pattern formed by dark spots. The hind leg has transverse stripes.

The Marsh Frog reproduces from the beginning of May through at water temperatures of 15–20°C. The vocal activity of males lasts after the breeding season. In the breeding season, the male choruses are heard during the day and night and stop before morning from 0300–0600 h (the coldest time). The mating calls do not stop even at air temperatures down to 4°C. The male call, as well as for other frogs of the green frog group, is an acute croaking or loud rumbling "uorrr..." or "crouu ..." that can be heard at a distance to 2–3 km.

Amplexus is axillary. Clutches occur in lumps of irregular shape that are deposited, as a rule, on a depth of 0.6–1.3 m. The number of eggs varies from 1032–6200. Tadpoles

are colored in olive tints and grow to 80–100 mm. The gill opening of the tadpole is located on the left side and directed backwards and upwards. The dimensions of metamorphs vary from 17–35 mm.

This species has a strictly littoral mode of life. It lives and breeds in large water bodies with stagnant or flowing water such as lakes, water storage basins, ponds, rivers, dead channels and drainage channels. Quite often it occurs along rivers and pools in suburbs.

Marsh Frogs hibernate in the same water bodies where it lives in the warm season. It starts to hibernate earlier than the Common Frog (also hibernating in water) at the end of September–October at water temperatures of below 8–10°C. In the non-freezing ponds of the coolers of the Belozersk Water Power Station, some Marsh Frogs are active throughout the winter (Pikulik, 1985). In Belarus it is distributed unevenly and the population density varies from 1–2 to 300–550 specimens/100 m of shoreline.

The diet is highly variable. When fish fry and amphibian larvae are abundant, the proportion of aquatic prey attains 70% (Pikulik, 1985). In some localities ground insects play a considerable role in feeding (to 80–90%). According to the data from E.E. Padutov (1983), in different ponds of several fish farms in the Gomelskaya Province, the food of the Marsh Frog includes diving beetles (22.9%), spiders (11.9%), mosquitoes (9.9%), flies (9.2%) and ground beetles (6.3%). Because of the large body size in this species, it consumes also large prey like small mammals (voles, shrews) and nestlings of passerine birds (Bannikov et al., 1977). Spawn, tadpoles and adults of the Marsh Frog are eaten by leeches, aquatic insects (Dytiscidae, Odonata), fishes, Grass Snakes, waterfowl, muskrats, mustelids and foxes. This species contains the richest fauna of parasitic helminths of all amphibian species.

The destruction of water bodies is the main negative factor affecting populations of the Marsh Frog. Among others, urbanization and recreation are important. In comparison with other amphibians, this species is notable by its high resistance to chemical pollution. The increase of number of this species over large areas is promoted by creation of drainage channels and building of polder systems in Byelorussian Polesie and other regions.

Pool Frog, *Rana lessonae* Camerano, 1882

Color Plate 12.

The Pool Frog has a large geographic range. It is distributed in western Europe from southern France to northern Germany and from central Europe north to Stockholm in Sweden. The northern margin of the distribution is in Estonia and northwestern Russia. The southern margin of the geographic range is in southern Ukraine and northeastern Russia (Kuzmin, 1999).

Subspecies are not recognized.

The Pool Frog belongs to the complex of green frogs (*R. esculenta* complex) where interspecific hybrids are known. The specific identification of the Pool Frog in Belarus (except differentiation by standard morphological characters) was confirmed by electrophoresis of blood serum albumins for frogs from Verkhnedvinskii District (surroundings of Osveyskoe Lake) and near Ratomka Village in Minskii District (Pikulik, 1985). The most precise method for diagnostics of all green frog species is DNA-cytometry and electrophoretic mobility of blood serum proteins (Tsaune, 1987). Distribution of the Pool Frog in Belarus is shown in Fig. 27.

This species is the smallest green frog among those distributed in Belarus; the body length does not exceed 75.7 mm (Table 13). It is one of the best studied species of amphibians in morphology.

The tint of the dorsal coloration varies from yellowish-green to brightly green. However, quite often there are specimens that have a grey or brownish color. About 90% of individuals have a pale medial stripe and light lines on the side folds. In some individuals the pattern is expressed very weakly. The temporal spot is absent. The belly, as a rule, has no pigmentation

Fig. 27. Distribution of *Rana lessonae* in Belarus.

Table 13. Size and body proportions of *Rana lessonae* from the territory of Belarus (n = 259).

Characters	Males (n =138)		Females (n=121)		t-criterion
	M±m	min-max	M±m	min-max	
L	53.42 ±5.735	42.3 – 75.7	57.91 ± 8.285	40.3 – 73.1	
L.c	17.66 ± 1.765	13.9 – 23.9	18.63 ± 2.537	12.8 –23.4	
Lt.c	18.09 ± 1.929	14.0– 25.2	19.86 ± 2.852	13.9 – 25.2	
D.r.o	8.20 ± 0.904	6.10– 11.7	8.67 ± 1.244	4.5 – 10.8	
L.o	4.63 ± 0.775	3.10– 8.30	4.7 ± 0.781	2.9 – 6.60	
L.tym	3.61 ± 0.550	2.6 – 6.00	3.79 ± 0.588	2.3 – 5.2	
Sp.o	7.31 ± 0.673	5.9 – 9.50	7.67 ± 0.860	5.4 – 9.2	
F	24.16 ± 2.931	18.80–33.2	25.08± 3.432	17.10 - 32.6	
T	23.85 ± 2.642	18.7– 33.4	24.73 ± 3.164	16.8 – 30.4	
C.s	14.72 ±1.591	11.2– 21.0	15.35 ± 2.201	11.0 – 28.3	
P	29.74 ± 3.26	22.7 – 40.6	30.25 ± 4.003	21.3 – 38.3	
D.p	6.37 ± 0.795	4.5 – 9.3	6.71 ± 1.009	4.4 – 8.8	
C.int	3.91 ± 0.501	2.8 – 5.0	4.09 ± 0.585	2.5 – 5.30	
L/L.c	3.03 ± 0.138	2.69 – 3.69	3.11 ± 0.154	2.76 – 3.65	4.79
L.c/L.t.c	0.98 ± 0.047	0.83 – 1.10	0.94 ± 0.048	0.75 – 1.08	6.51
L.c/L.o	3.88 ± 0.451	2.21– 5.19	4.00 ± 0.400	3.21 – 5.43	2.33
L.o/L.tym	1.29 ± 0.185	0.92– 2.18	1.25 ± 0.157	0.97 – 1.67	1.97
L.c/D.r.o	2.16 ± 0.117	1.77 – 2.44	2.16 ± 0.279	1.71 – 4.40	0.16
D.r.o/L.o	1.80 ± 0.209	1.01 – 2.38	1.86 ± 0.207	0.94 – 2.49	2.79
Sp.o/D.r.o	0.90 ± 0.073	0.74 – 1.25	0.89 ± 0.110	0.74 – 1.80	0.02
L/T	2.24 ± 0.093	2.01 – 2.50	2.34 ± 0.099	2.10 – 2.60	8.14
F/T	1.01 ± 0.050	0.89 –1.12	1.01 ± 0.04	0.91 – 1.12	0.02
L/(F+T)	1.11 ± 0.047	1.01 – 1.33	1.16 ± 0.048	1.02 – 1.28	8.13
T/C.s	1.62 ± 0.058	1.46 – 1.81	1.61 ± 0.068	1.07 – 1.74	0.48
L/C.int	13.72 ± 0.848	11.71-15.79	14.21 ± 0.927	10.10 – 16.51	4.11
T/C.int	6.12 ± 0.385	5.25 – 7.03	6.08 ± 0.425	4.54 – 7.02	1.06
D.p/C.int	3.86 ± 0.652	2.55 – 6.75	1.65 ± 0.153	1.08 – 2.04	0.27

and is milk-white in color. There are intrapopulational differences in the frequency of occurrence of different variants of the dorsal pattern (e.g., striata and maculata morphs).

The morphological features of the Pool Frog include relative length of hind leg and form and dimensions of the inner metatarsal tubercle. This species is remarkable in having short legs (the talocrural joints in the position when the thighs are posited perpendicularly to the main long axis of body do not touch), a wide and tall inner metatarsal tubercle that it white and shorter than the 1st toe by 0.8–2.04 times.

Thus, from the Pool Frog to the Marsh Frog the relative length of the hind legs increases, and the relative size of the inner metatarsal tubercle decreases. These morphological features allow field identification of green frogs. More precise diagnostics are based on the application of cluster analysis of the indices D.p/C.int and T/C.int (Tsaune, 1987).

The degree of variability of particular characters in the Pool Frog is less than in the two other species of this group. Sexual dimorphism is expressed only in three characters of

diagnostic value: L/T, F/T and D.p/C.int. Female body proportions are characterized by greater variability than those in males. Males have nuptial pads on the 1st finger and a pair of white vocal sacs.

The Pool Frog lives in small ponds and riparian areas of lakes, mainly in basins with light flow, or in ditches, whose the shores are densely overgrown. In contrast to the Marsh Frog, the Pool Frog occurs often in humid lowland forests (alder, oak woods) and also in floodplain sedge meadows. For example, in Belovezhskaya Pushcha 43.1% of individuals were observed away from water (Bannikov and Belova, 1956). Similarly to other species of green frogs, the Pool Frog is found to riparian areas. In coastal ecosystems of Belarus the population density of the Pool Frog usually varies from 5–10 to 80 individuals/100 m of shoreline.

Tadpoles feed mainly on algae (Cyanophyta, Chlorophyta). Diptera and their larvae prevail in the food of metamorphs. Ground dwellers compose the main part of the diet of adults (to 65%: Bannikov et al., 1977). In Byelorussian Poozerie, the proportion of Odonata larvae composes 14.8% of the prey, Gastropoda 13.6%, aquatic Coleoptera 13.5%, and Diptera 12.7%. In fish ponds of the Gomelskaya Province, Aranei (16.8%), Dytiscidae (15.0%), Odonata (14.8%), mosquitoes (11.7%), Mollusca (11.2%) and some other prey were found (Padutov, 1983). Pool Frogs also eat fish spawn and young fishes in fishery ponds.

This species has many natural enemies: different species of fishes, amphibians (*R. ridibunda*, *B. bufo*), reptiles (*Natrix natrix*), mammals (*Ondatra zibethica*, *Lutra lutra*, *Mustela lutreola*). Cannibalism is common in the forms of larva – larva, larva – egg and adult – metamorphs.

The Pool Frog is resistant to anthropogenic factors. It successfully adapts to modified conditions of transformed landscapes. It permanently occurs in ponds in large cities, and quite often is numerous in fishery ponds, water storage reservoirs and drainage channels. Urbanizaton of natural landscapes, destruction of ponds and building of the concrete embankments in urban water bodies are negative effect on the populations.

Edible Frog *Rana esculenta* Linnaeus, 1758

Color Plate 13.

The Edible Frog represents an example of non-orthodox speciation in vertebrate animals. *Rana esculenta* is of a hybrid origin from *R. ridibunda* and *R. lessonae* (Berger, 1967, 1968; Guenther, 1990). According to modern concepts, it is a clepton with character that do not coincide with the biological species concept (Kuzmin, 1999). The hybrid *R. esculenta* is represented by individuals with the genotype of one of the parents, and the genome of another parent is eliminated during gametogenesis.

Hybrids are capable of living in mixed groups with one parent species, most often *R. lessonae*. There is a great diversification of "pure" and "mixed" population systems in these

three forms of green frogs: L, R, RL, LE, RE, E, RLE (Tsaune, 1987; Lada et. al., 1995). The systematic relations of *R. esculenta*, *R. ridibunda* and *R. lessonae* remain a subject of discussion.

Subspecies are not distinguished.

The range of geographical distribution of the Edible Frog is not fully known. According to S .L. Kuzmin (1999), the margin of the geographic range is in Estonia, Latvia, Belarus (Nesvizhskii District, Alba Fishery: about 53°10'N, 26°40'E), Russia and Ukraine. The geographical distribution and intraspecific variability requires further researches because the majority of old records of "*R. esculenta*" may belong to the two other species of green frogs.

The populations of the Edible Frog in Belarus remain practically unknown. Its presence has been verified by biochemical tests only in the above mentioned locality (Pikulik, 1985). We determined the species presence elsewhere based on morphological criteria (Tsaune, 1987). Distribution of this species is shown in Fig. 28.

The most characteristic difference of the Edible Frog is hind leg length and color of the vocal sacs. If one presses the thighs to shins and arranges them perpendicularly to the

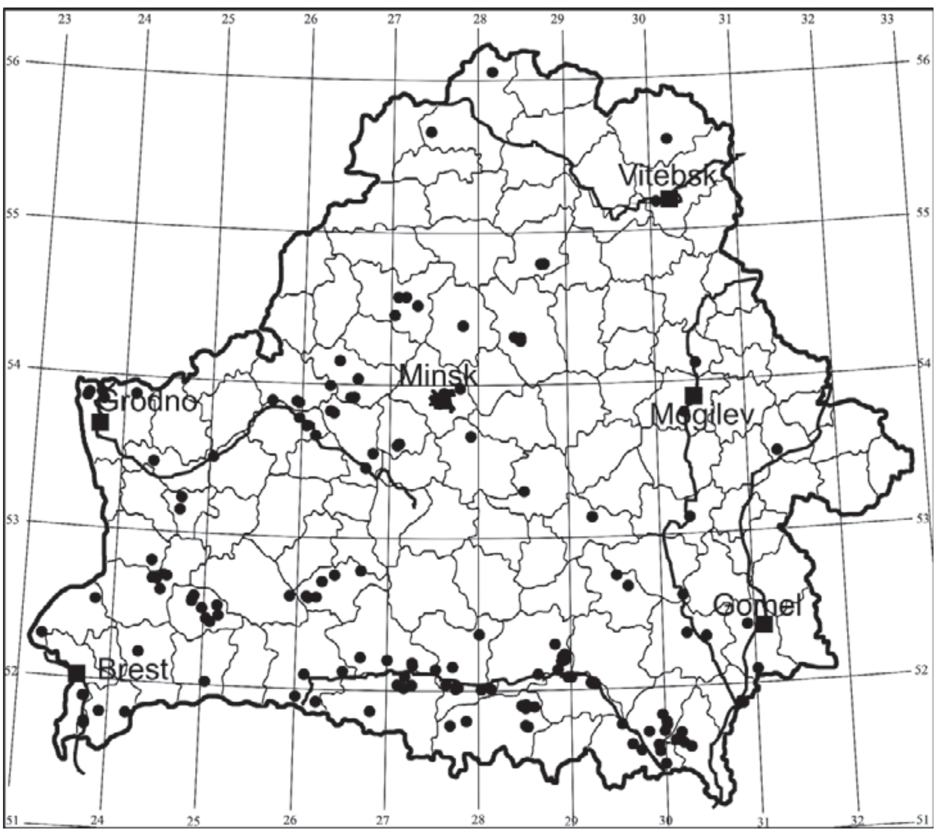


Fig. 28. Distribution of *Rana esculenta* in Belarus.

body axis, the talocrural joints adjoin each other (Fig. 29). The inner metatarsal tubercle is higher than in the Marsh Frog (Fig. 30). The color of the vocal sacs of most males is grey. Coloration, as a rule, is very bright green, sometimes with an olive tint. On the back (90.7%) a longitudinal stripe, extends from the point of the snout to the anus, is usually present. The shape and width of this stripe are rather variable; 14.6% of 239 individuals had large, clear, contoured spots on the back. The belly is pale milk-white. Individuals with spotted bellies (21.7%) and throats (40.2%) are also found.

Fig. 29. The position of talocrural joints in *Rana esculenta* when one presses the thighs to the shins and arrange them perpendicularly to the main body axis. Nesvizh and the sources of the Lan River.

Fig. 30. Inner metatarsal tubercle of *Rana esculenta*.

As the hybrid origin of the Edible Frog presupposes combination of a complex of characters typical for the parent forms, it is characterized by a considerable plasticity of all of morphometric parameters. The sexual dimorphism is the same as in other green frogs. According to our data, it is clear for the characters L.c/Lt.c, L.c/L.o, L.c/D.r.o, D.r.o/L.o, S.p.o/D.r.o, L.o/L.tym, L/(F+T) and T/C.int. Detailed morphometric data of the species are given in Table 14.

In Belalrus, the Edible Frog inhabits water bodies situated in a wide spectrum of natural and anthropogenic ecosystems, as this species participates in forming of mixed population systems of LE, RE and RLE-types. The systems of a RLE-type make 32% of all inspected water bodies (n=42). They were found in Berezinskii, Borisovskii, Pruzhanskii, Stolinskii, Zhitkovichskii and Mozyrskii districts. The RE-type was found in 8% localities in Miorskii, Grodnenskii, Stolinskii and Rechitskii districts, LE-type in 52% of practically all localities throughout Belarus. Males and females have almost equal shares in populations.

Table 14. Size and body proportions of *Rana esculenta* from the territory of Belarus (n=204).

Characters	Males (n=153)		Females (n=135)		t-criterion
	M±m	Min-max	M±m	min-max	
L	63.99 ± 6.904	47.4 – 79.2	55.19 ± 12.92	40.1 – 88.3	
L.c	20.75 ± 2.312	14.7– 26.9	18.03 ± 3.87	12.3 – 27.6	
Lt.c	21.85 ± 2.359	16.1 – 28.0	19.40 ± 4.29	13.6 – 31.4	
D.r.o	10.00 ± 1.423	7.5 – 19.80	8.81 ± 1.927	5.7 – 14.8	
L.o	5.41 ± 0.851	3.7 –9.8	4.50 ± 1.112	2.8 – 7.70	
L.tym	4.38 ± 0.049	2.5 – 5.9	3.78 ±0.971	2.10 – 6.80	
Sp.oc	8.51± 0.070	6.5 – 11.2	7.73 ± 1.386	5.2 – 11.4	
F	29.36 ± 0278	19.7 – 37.2	24.97 ± 6.23	14.5 – 39.8	
T	30.34 ± 0.268	21.6–40.10	25.93±6.016	16.3 – 41.10	
C.s	17.86 ± 0.158	12.6 – 21.8	15.40 ±3.500	10.10 – 24.10	
P	35.29 ± 0.301	25.7 – 43.5	30.24 ± 6.692	20.4 – 48.0	
D.p	8.43 ± 0.088	5.6 – 10.8	7.18 ± 1.805	4.4 – 12.7	
C.int	3.79 ± 0.040	2.5 – 5.10	3.25 ± 0.916	1.80 – 5.80	
L/L.c	3.09 ± 1.124	2.81 –3.54	3.054 ± 0.166	2.65 – 3.79	1.89
L.c/L.t.c	0.95 ± 0.047	0.76 – 1.07	0.93 ± 0.048	0.78 – 1.11	3.34
L.c/L.o	3.88 ± 0.413	2.07 – 4.82	4.06 ± 0.416	3.25 – 5.09	3.67
L.o/L.tym	1.24 ± 0.164	0.92 – 1.19	1.20 ± 0.150	0.90 –1.71	2.23
L.c/D.r.o	2.09 ± 0.129	1.03 – 2.30	2.05 ± 1.106	1.71 – 2.28	2.86
D.r.o/L.o	1.86 ± 0.190	1.11 – 2.28	1.99 ± 0.22	1.43 – 2.63	5.16
Sp.o/D.r.o	0.86 ± 0.070	0.41 – 1.05	0.89 ± 0.072	0.74 – 1.10	3.22
L/T	2.11 ± 0.099	1.81 – 2.37	2.13 ± 0.105	1.89 – 2.55	1.58
F/T	0.97 ± 0.045	0.77 – 1.08	0.960 ± 0.052	0.74 – 1.09	1.19
L/(F+T)	1.07 ± 0.047	0.95 –1.23	1.09 ± 0.051	0.964 – 1.250	2.37
T/C.s	1.70 ± 0.056	1.56 –2.11	1.68 ± 0.065	1.47 – 1.85	2.38
L/C.int	16.97 ± 1.40	14.2 – 20.8	17.26 ± 1.53	13.90 – 23.06	1.65
T/C.int	8.05 ± 0.651	6.77 – 9.85	8.11 ± 0.754	6.02 – 9.91	0.81
D.p/C.int	5.84 ± 1.00	3.50 – 8.67	2.24 ± 0.226	1.60 – 2.79	0.24

The Edible Frog is characterized by greater ecological plasticity than its parental forms. This species is widely distributed in flowing water, shallow lakes and ponds. The frogs hibernate in water and on land if there are suitable shelters not far from water. The number in natural ecosystems rarely exceeds 5–10 specimens/100 m of shorelines. In Polesie in the floodplain of the Pripyat, high densities were recorded on the banks of by-pass channels on the drainage system of polder type (Khlupin and Bakov villages).

The effects of anthropogenic factors are ambiguous. Edible Frogs, according to published data, are highly resistant to urbanization and are rather common in settlements, villages and even big cities where it lives in various water bodies. The negative factor of anthropogenic nature is the destruction of wetlands suitable for breeding. Among natural conditions a limited number of suitable habitats affect its relatively narrow distribution and small numbers.

CHAPTER 4.

STRUCTURE OF ASSEMBLAGES AND SYNECOLOGY

The amphibian fauna of Belarus, which is situated in the temperate zone of Europe, contains a small number of species but is peculiar in their large ecological variety, considerable variability of structural organization of populations, wide spectrum of populated ecosystems, and high number. Because of their high breeding performances and biological productivity, amphibians have an important role in terrestrial and semiaquatic ecosystems and are quite often a trophic basis for vertebrates.

Assemblages of amphibians are interesting models for understanding mechanisms and principles of sustainable functioning of natural communities, analysis of matter and energy turnover, and various other ecosystem processes. A theoretical understanding of complex ecological processes is necessary for finding solutions to many of the actual problems associated with the problems of conservation of biological diversity. Conservation of the majority of biological species is impossible without analysis of the state of their biotic environment and maintenance of existing structure of their ecological niches (Pianka, 1981; Giller, 1988).

4.1. Dynamics of Faunistic Complexes

As indicated above, 11 species of Anura and 2 species of Caudata occur in Belarus. Recent studies have shown polymorphism of some taxa (e.g., Crested Newt and the Spadefoot (Litvinchuk et al., 2003; Borkin, 2001) which, at the expense of increase of their taxonomic rank, can expand the list of the regional fauna. The majority of amphibian species in Belarus compose a core of amphibians of a large natural region – forest zone of Europe.

The analysis of data on structural organization of amphibian complexes in Belarus demonstrate their high spatial variability connected to the influence of the two main factors:

1) climatic-geographical conditions that influence differences of faunistic composition in different natural regions; and

2) landscape-ecological differentiation of the territory and anthropogenic transformation of ecosystems that determine the local diversity of assemblages.

The original formation of the recent amphibian fauna of the region was connected to its geographical position, climatic conditions, their fluctuations and, in particular, with

the history of last glacial processes. The distribution of most amphibian in Belarus and adjacent territories of Eastern Europe took place in Pleistocene–Holocene about 10,000 years ago (Borkin, 1984; Pikulik, 1993). Slow melting of the last two glaciers (Sozh and Poozerie) promoted northward movement of amphibians. The most ancient and rich fauna belongs to the southern Byelorussian Polesie which was not affected by the last glaciation.

At present, restricted distribution in Belarus is displayed by the most thermophilous species that occur on the northern, northeastern or eastern limits of their geographic ranges. The recent range of the Common Tree Frog, a component of the Mediterranean fauna, approximately corresponds with the limits of the penultimate (Sozh) glaciation that did not affect the southern part of the Republic, Byelorussian Polesie. The Fire-Bellied toad had not been distributed in the northern part of the region of Byelorussian Poozerie and the Natterjack Toad can settle only in the southwestern regions of the Republic (Fig. 2). Distributions of these species are correlated with the duration of the growing season (the number of days with average daily temperature of air higher then 5°C).

Based on the distributional patterns and numbers of species, most are eurytopic, or ecologically plastic: Moor and Common Frogs occur, respectively, in 42.1 and 28.1% of different ground and semiaquatic ecosystems (Table 15). The mean density of populations of these species is 340.0±21.8 and 283.6±19.3 specimens/ha.

Green frogs of the hybrid complex (*R. esculenta*) were recorded in 16.2% of all inspected ecosystems with an average population density of 348.5±19.6 specimens/ha. They are subdominants in the structure of amphibian complexes. In connection with difficulty in

Table 15. Distribution, relative number (density) of populations and conservation status of different species of amphibians in Belarus.

Species	**Parameters**			
	Distribution	**Occurrence in the ecosystems**	**Mean level of density, specimens per hectare**	**Conservation status**
T. vulgaris	A	2.9	56.2 ± 3.7	C
T. cristatus	A	0.8	133.6 ± 11.5	R
B. bombina	L	7.6	459.1 ± 32.8	C*
P. fuscus	A	2.5	16.1 ± 1.9	C
B. bufo	A	7.6	52.0 ± 4.9	C
B. viridis	A	1.5	65.3 ± 6.6	C
B. calamita	L	1.2	400.0 ± 31.8	R, RB
H. arborea	L	3.9	100.2 ± 8.9	C*
R. esculenta complex	A	16.2	348.5 ± 19.6	D
R. arvalis	A	42.1	340.0 ± 21.8	D
R. temporaria	A	28.5	283.6 ± 19.3	D

Note: A – Distribution of a species covers whole the territory of Belarus; L – geographical range is limited; D – dominant or subdominant; C – common; C* – common in the limits of the zone of distribution; R – rare; RB – included in the Red Data Book of Belarus.

precise field identification of different species of this group, green frogs hereafter are considered as a combined group.

A majority of the remaining amphibians (*T. vulgaris, B. bombina, P. fuscus, B. bufo, B. viridis*) was included in the group of species common for the region that are distributed in 1.5–7.8% of the ecosystems with populations densities of 16.1–459.1 specimens/ha. The rarest are the Natterjack Toad and the Crested Newt, stenotopic species characterized by the narrowest range of habitats. These amphibians occur in only 1.2% of the ecosystems but are capable of locally high population densities (400.0±31.8 and 133.6±11.5 specimens/ha).

The structural organization of faunistic complexes of amphibians is notably connected with geographical zonality and natural differentiation of the territory of Belarus.

The southern part of the Republic, Byelorussian Polesie, for which the greatest species diversity and heterogeneity of amphibian complexes composition is typical, is especially strongly distinguished in this respect. In natural communities of this region, that is situated in the subzone of broad-leaved–pine forests and distinguished by large areas of swamps and forests, Moor Frogs inhabit 52.7% of the ecosystems (Fig. 31, Table 16). The important role in structural organization of natural associations also is played by green frogs (25.1%), Fire-Bellied toad (14.7%), Common Frog (11.5%) and Tree Frog (7.2%). The mean number of species, which are included in a composition of amphibian associations, is 1.95, Simpson index (*I*) 0.835.

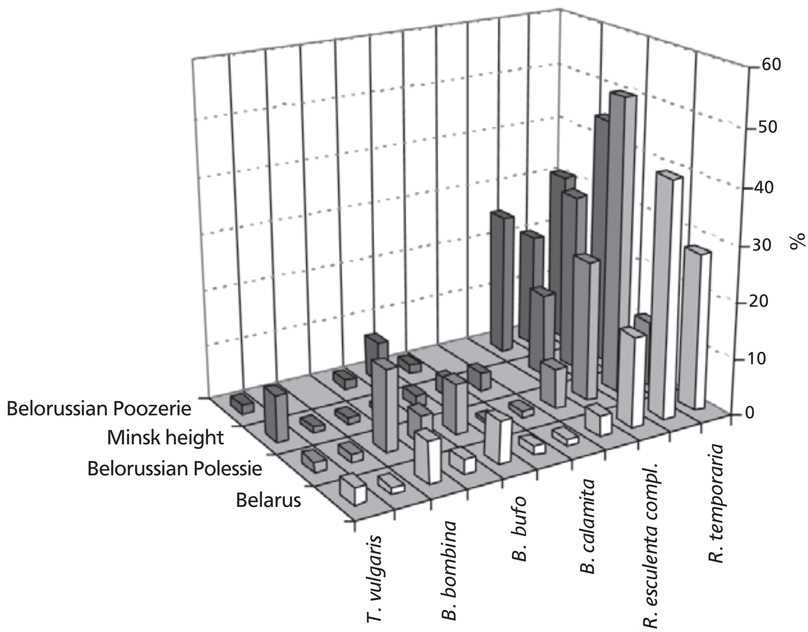


Fig. 31. Variability of species composition and structural organization of amphibian communities at different localities of Belarus.

Table 16. Specific diversity and density of population of amphibians of different natural and administrative regions of Belarus.

Regions	Simpson index	Number of species in associations		Population density, specimens/ha		
		max	M	min	max	M
Belarus Natural regions	0.816	7	1.86	0.4	10733.3	531.7
Belorussian Polesie	0.835	7	1.95	0.5	10733.3	600.1
Minsk Elevation	0.814	6	1.81	2.4	8000.0	630.7
Belorussian Poozerie						
Administrative provinces	0.831	5	1.59	0.4	9345.0	420.4
Brestskaya (southwest)	0.812	7	1.96	0.5	9600.0	458.1
Gomelskaya (southeast)	0.840	7	1.97	1.0	10834.2	657.9
Grodnenskaya (west)	0.752	7	1.81	10.0	1477.0	239.5
Minskaya (center)	0.814	6	1.81	2.4	8000.0	624.6
Mogilevskaya (east)	0.738	5	1.92	6.0	5895.0	430.2
Vitebskaya (north)	0.847	5	1.61	0.4	10425.0	438.4

In the central part of the Republic, on the Minsk Height that belongs to the subzone of hornbeam–oak–dark-coniferous forests and undergoes the greatest degree of urbanization of natural ecosystems, the Common Frog dominates in population structure by inhabiting 44.7% of habitats. The Moor Frog occupies the second place by its abundance. It uses a little narrower spectrum of habitats (31.9%). A considerably smaller role belongs to the green frogs which live in 14.9% of ecosystems. Rather common is the Smooth Newt (8.5%).

The poorest species structure and more homogeneous amphibian complexes are indicative of the northern part of the Republic, Byelorussian Poozerie that is situated in the subzone of oak–dark coniferous forests. The Common Frog is dominant (31.0%); co- or subdominant is the Moor Frog (20.6%). Wide distributions in this region include the Common Toad which occurs in 7.1% of all amphibian habitats. The number of species that compose associations in the region of Poozerie is minimum, 1.59; the index of species diversity is 0.831.

Other important parameters of spatial heterogeneity of faunistic complexes of amphibians are the total abundance of their populations. Population density of the of assemblages of amphibians is the greatest on the Minsk Height, an average of 630.7±31.4 specimens/ha, a little lower in Byelorussian Polesie, 600.1±21.5 specimens/ha, and a minimum in Byelorussian Poozerie, 420.4±11.4 specimens/ha.

Essential differences in specific and structural diversity of amphibian populations are displayed in different administrative provinces of the Republic (Table 16). The greatest species diversity is characteristic for Gomelskaya Province situated in southeastern Belarus where the average number of species in associations is 1.97; in Brestskaya Province (southwest) 1.96, Mogilevskaya Province (eastern part) 1.92; the least in Vitebskaya Province (northern part) 1.61.

4.2. Structural Organization of Assemblages

At present, rather simply organized, 1-, 2- and 3-species associations play leading roles in the structural organization of amphibian assemblages in various ecosystems of Belarus. Their sum is 94.9% (Fig. 32). The most complex (i.e., rich in species) are 7-species groups. However, their share in the population does not exceed 0.3%. In composition of natural communities, where the number of species is highest, the most common species are Moor, Common and green frogs, Smooth and Crested newts, Fire-Bellied Toad, Common Spadefoot, Green Toad and Tree Frog.

As evident from the cited data, the increase of degree of structural complexity of assemblages of amphibians by the amount of linking species is accompanied by quite natural reduction of their contribution to the populations. It is absolutely obvious, that both natural assemblages as a whole, and included in their composition taxonomic groups, a certain limit of saturation by species and number not exceeding particular level of supply by limited ecological resources and potential niches is present.

Analyses prove the essential peculiarities of different species by their tendency to use joint habitats (Fig. 33). The increase in numbers of assemblage members corresponds with increasing in their share in population. This tendency is especially indicative for all species of true frogs, which are the most adapted in this attitude. On the other hand, some species obviously escape inter- and, in particular, multi-species communities. A typical member of this group is the Natterjack Toad, clearly preferring communities, which are species poor. The ranking of species by the degree of their involvement in the interspecific groups

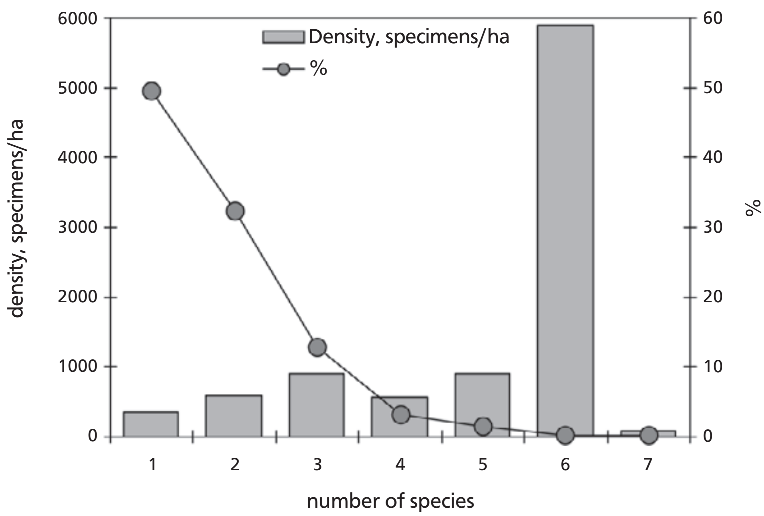


Fig. 32. Dependence of total amphibian density on the number of amphibian species in assemblages.

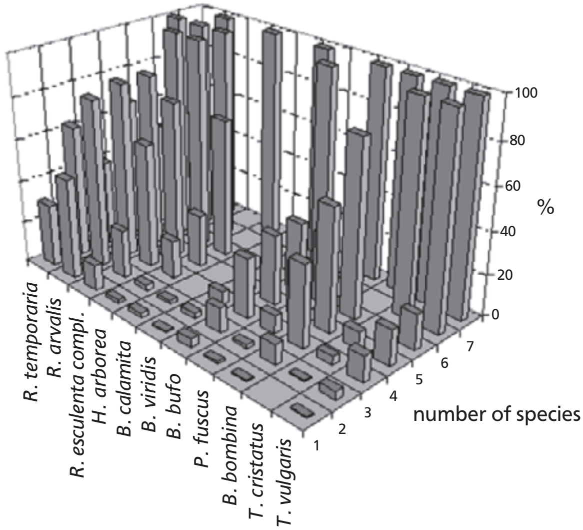


Fig. 33. Relative occurrence of amphibian species in assemblages that differ in the number of species.

(tendency to associate) is close to that observed in the structure of dominance of the amphibian populations (Table 17). The density of amphibian populations vary insignificantly by sample plots (Fig. 34).

The minimum area of the sampling plot containing representative data on the number of species in a community in Belarus is about 1000–1200 m^2 that corresponds with a point at which the curve of dependence reaches a plateau. The majority of species are found after 1–3 censuses and only the rarest ones, whose number does not exceed 5%, can be recorded only after longer and careful searches.

Table 17. Degree of pairwise conjugacy of spatial distribution of amphibian populations in Belarus.

Species	**Species**										
	T. vulgaris	*T. cristatus*	*B. bombina*	*P. fuscus*	*B. bufo*	*B. viridis*	*B. calamita*	*H. arborea*	*R. esculenta* complex	*R. arvalis*	*R. temporaria*
T. vulgaris	–	17.7	29.4	5.9	5.9	11.8	0	11.8	41.2	52.9	41.2
T. cristatus	60.0	–	40.0	20.0	20.0	20.0	0	20.0	60.0	80.0	20.0
B. bombina	11.1	4.4	–	6.7	8.9	6.7	0	24.4	71.1	62.1	17.8
P. fuscus	6.7	6.7	6.7	–	26.7	13.3	6.7	26.7	20.0	80.0	26.7
B. bufo	2.2	2.2	8.9	8.9	–	0	0	4.4	24.4	64.4	40.0
B. viridis	22.2	11.1	33.3	22.2	0	–	22.2	22.2	11.1	33.3	22.2
B. calamita	0	0	0	14.3	0	28.6	–	0	14.3	14.3	14.3
H. arborea	8.7	4.3	47.8	17.4	8.7	8.7	0	–	47.8	60.9	17.4
R. esculenta complex	7.6	3.3	34.8	3.3	12.0	1.1	1.1	12.0	–	53.3	18.5
R. arvalis	3.6	1.6	11.2	4.8	11.6	1.2	0.4	5.6	19.6	–	38.4
R. temporaria	4.1	0.6	4.7	3.0	11.2	1.2	0.6	3.0	10.1	56.8	–

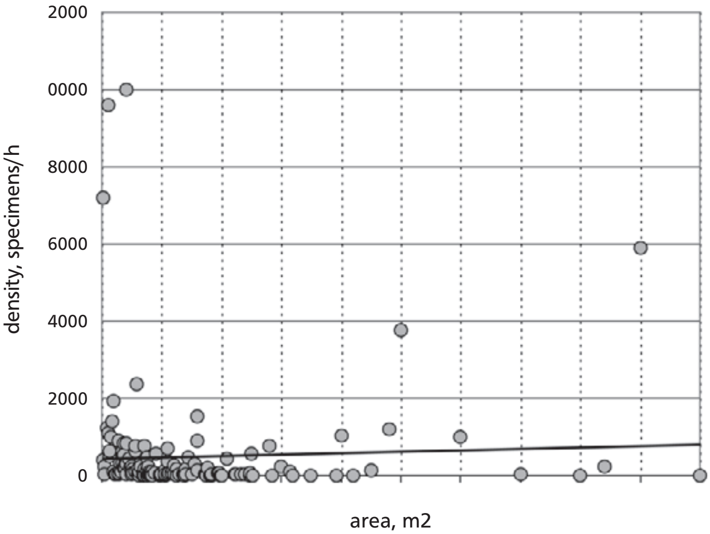


Fig. 34. Dependence of population density in amphibian assemblages based on the size of the sampling plots.

4.3. Habitat Distribution and Population Number

Analysis of the ecological parameters of amphibian habitats has shown that hydrological regimes and fertility of the lands are especially important. Structure of vegetation is an integral parameter of habitat conditions which affect microclimate, protective features of habitat, and composition of invertebrates which provide food resources for amphibians. Hydrology of the landscape and, especially, topography, structure and natural regimes of water bodies determine breeding, potential possibilities of population growth and, finally, viability of amphibian populations.

Specific and quantitative compositions of faunistic complexes of amphibians in the temperate climate zone are subject to considerable rearrangement during the season of activity connected with the change of seasons. It is affected by weather and climate, seasonality of landscapes, and complex physiological cycles of amphibians. In this connection, it is necessary to differentiate analysis of habitat distribution of amphibians, for which the annual cyclic change of habitats is typical, from the number of basic periods: breeding season, summer season and hibernation.

Summer allocations of the amphibian populations were estimated by 10 groups of predominant ecosystems distinguished on the basis of a classification of plant associations (Vegetative Cover of Byelorussia, 1969; Yurkevich et al., 1979) (Table 18). For the analysis of habitat distribution, we omitted data on ecotones (zone of contact of different ecosystems), which produce an essential effect on the species composition and number of assemblages.

Table 18. Summer distribution of amphibian populations by the main groups of ecosystems in Belarus.

Ecosystems	Parametres				
	Number of species			Total density	Simpson index
	min	M	max		
Birch stands	1	2.4	5	172.6 ± 10.4	0.178
Raised bogs	1	2.2	3	41.8 ± 3.2	0.191
Oak stands	1	2.5	4	575.9 ± 35.4	0.148
Spruce stands	1	1.75	3	235.0 ± 19.3	0.134
Mixed forests	1	1.0	4	74.8 ± 5.7	0.100
Dry meadows	1	2.2	4	248.8 ± 19.4	0.166
Flood plane meadows	1	2.3	5	905.6 ± 56.9	0.145
Alder stands	1	1.8	4	795.0 ± 65.7	0.136
Humid pine forests	1	1.6	4	107.3 ± 9.3	0.126
Dry pine forests	1	1.3	2	80.0 ± 7.1	0.123

The results of the analysis have shown that the highest density of amphibian populations occurs on lowland meadows (mean level 905.6±56 specimens/ha), in black and grey alder forests (795.0±65.7), and in oak woods (575.9±35.4). Therefore, the highest number of amphibians is connected with the most productive phytocenoses formed on the most fertile soils (soda-podzol, swamp turf and swamp soda-podzol).

The mean density is typical for upland meadows (248.8±19.4 specimens/ha), spruce stands (235.0±19.3), birch stands (172.6±10.4) and humid pine forests (107.3±9.3). The minimum values were obtained for raised bogs (41.8±3.2 specimens/ha), different types of mixed forests (74.8±5.7) and dry pine forest (80.0±7.1).

A little different picture is typical for the distribution of species diversity of amphibians by main groups of ecosystems. The following ecosystems were found to be optimal for amphibians: oak woods, communities which include an average of 2.5 amphibian species, birch stands (2.4) and lowland meadows (2.3). In remaining ecosystems faunistic diversity scales down in the following order: raised bogs (2.2) – upland meadows (2.2) – spruce stands (1.75) – alder forests (1.8) – humid pine forests (1.6) – dry pine forests (1.3) – mixed forests (1.0).

Tables 19 and 20 contain data on relative occurrence, mean values of density, and typical interspecific associations of various species in different (wood, meadow, bog) ecosystems of Belarus. These tables show that almost each species is timed to a particular spectrum of ecosystems.

Our studies allowed the discovery of some principles in structural organization of ecological complexes of amphibians. Different species definitely replace each other over the gradient of the main ecological factors (humidity, temperature and illumination of habitat) that correspond to the rule of ecological ordination (Tables 21 and 22). The data also indicated another important principle of organization of natural communities – bound with their continuity, the communities of living organisms continuously grade one into another without forming discrete structures).

Table 19. Relative occurrence of different species of amphibians in basic groups of ecosystems in Belarus.

Ecosystems	Relative occurrence, %										
	T. vulgaris	*T. cristatus*	*B. bombina*	*P. fuscus*	*B. bufo*	*B. viridis*	*B. calamita*	*H. arborea*	*R. esculenta*	*R. arvalis*	*R. temporaria*
1. Birch stands	25.0	–	–	–	–	–	–	–	–	62.5	37.5
2. Raised bogs	–	–	–	–	–	–	–	–	–	75.0	50.0
3. Oak stands	–	8.3	16.7	8.3	16.7	–	–	8.3	33.3	91.7	25.0
4. Spruce stands	–	–	–	–	–	–	–	–	–	66.7	100.0
5. Mixed forests	–	–	–	–	–	–	–	–	–	66.7	33.3
6. Dry meadows	–	–	19.1	4.8	9.5	4.8	–	9.5	14.3	76.2	47.6
7. Flood plain meadows	4.6	–	18.2	4.6	13.6	–	4.6	4.6	36.4	59.1	45.5
8. Alder stands	–	9.1	9.1	–	18.2	–	–	–	27.3	81.8	27.3
9. Humid pine stands	12.5	–	–	–	12.5	–	–	–	–	62.5	37.5
10. Dry pine stands	–	–	–	–	–	–	–	–	–	100.0	50.0

The continual character of ecological complexes of amphibians was clearly tracked by analyzing their variability along typical ecological gradients from the most low and humid habitats to the elevated and dry ones.

Ecological ordination of different species and continual characters of structural organization of amphibian complexes were investigated in Pripyatskii National Park which is characteristic of a unique combination of "pristine" landscapes of Polesie with high taxonomic diversity of amphibians (Drobenkov, 2001). For this purpose, some landscape-ecological profiles extending from north to south and reflecting the whole spectrum of natural ecosystems in transition from the Pripyat Channel to dry pine forests were included. Estimation of species diversity and number of amphibian fauna was conducted in the ecosystems most typical for this region (Table 23):

I) riparian ecosystems (channel zone of the Pipiat river, its dead channels and mouths of its tributaries);

II) periodically flooded meadows;

III) floodplain oak woods;

IV) fen alder forests;

Table 20. Mean density of amphibian populations in main groups of ecosystems in Belarus

Ecosystems	Populations density, specimens per hectare										
	T. vulgaris	*T. cristatus*	*B. bombina*	*P. fuscus*	*B. bufo*	*B. viridis*	*B. calamita*	*H. arborea*	*R. esculenta*	*R. arvalis*	*R. temporaria*
1. Birch stands	17.2	–	–	–	–	–	–	–	–	209.0	19.1
2. Raised bogs	–	–	–	–	–	–	–	–	–	19.7	17.2
3. Oak stands	–	20.0	6.9	1.3	6.1	–	–	13.9	34.8	175.8	1580.0
4. Spruce stands	–	–	–	–	–	–	–	–	–	166.7	187.8
5. Mixed forests	–	–	–	–	–	–	–	–	–	108.4	7.6
6. Dry meadows	–	–	30.1	7.3	16.2	25.0	–	3.3	113.3	136.9	206.0
7. Flood plain meadows	21.0	–	156.4	5.0	40.4	–	5.0	6.7	67.2	346.4	1347.0
8. Alder stands	–	34.9	53.6	–	104.2	–	–	–	52.7	770.1	275.0
9. Humid pine stands	16.7	–	–	–	15.9	–	–	–	–	31.8	178.1
10. Dry pine stands	–	–	–	–	–	–	–	–	–	34.7	137.0

Table 21. Distribution of number (density) of amphibian populations and associations by degree of humidity of habitats.

Species	Habitat types				
	Extremely dry	**Dry**	**Medium humid**	**Humid**	**Riparian**
T. vulgaris	–	16.7	17.3	122.8	918.3
T. cristatus	–	–	7.9	132.5	202.5
B. bombina	–	–	16.0	152.5	1004.4
P. fuscus	14.4	14.3	20.8	9.1	41.7
B. bufo	20.4	15.9	20.1	31.4	157.4
B. viridis	7.7	86.3	25.0	6.1	97.1
B. calamita	5.0	18.2	5.0	4.0	922.1
H. arborea	–	–	–	137.5	51.6
R. esculenta ñomplex	–	1.9	76.2	136.9	573.9
R. arvalis	6.7	34.8	71.7	442.2	363.6
R. temporaria	11.8	75.9	94.8	411.5	288.3
Total density, spec./ha	3.5	23.4	62.8	488.8	724.4

Table 22. Distribution and dynamics of number (density) of amphibian populations by the degree of habitat illumination.

Species	Habitat types					
	Forest		Open		Ecotones	
	%	Density, specimens/ha	%	Density, specimens/ha	%	Density, specimens/ha
T. vulgaris	52.5	10.3 ± 9.1	12.5	123.5 ± 10.1	35.0	7.9 ± 6.7
T. cristatus	82.5	132.5 ± 11.1	–	–	17.5	5.0 ± 0.7
B. bombina	34.6	22.5 ± 2.5	30.8	93.9 ± 8.7	34.6	350.5 ± 31.9
P. fuscus	22.2	17.2 ± 12.4	22.2	8.7 ± 6.5	55.6	18.9 ± 1.9
B. bufo	32.3	31.1 ± 2.3	16.1	30.7 ± 3.2	51.6	27.2 ± 2.1
B. viridis	–	–	25.0	25.0 ± 2.6	75.0	7.6 ± 0.8
B. calamita	–	–	50.0	7.5 ± 6.8	50.0	11.6 ± 1.2
H. arborea	18.2	12.9 ± 1.1	27.2	6.1 ± 0.7	54.6	291.3 ± 3.9
R. esculenta complex	24.4	34.6 ± 3.7	36.6	81.7 ± 8.2	39.0	240.5 ± 2.7
R. arvalis	36.6	464.6 ± 32.0	20.1	188.7 ± 17.7	43.3	273.4 ± 25.9
R. temporaria	24.6	299.0 ± 19.0	21.6	552.0 ± 52.8	53.8	147.8 ± 14.5

Table 23. Variability of species composition, number (density) of amphibian populations and associations in ecological series of ecosystems in the Belorussian Polesie (territory of Pripyatsky National Park).

Species	Ecological series of habitats						
	Riparian ecosystems	Floodplain meadows	Oak forests	Alder forests	Low moors	Raised bogs	Pine forests
T. vulgaris	23.7 ± 2.1	–	14.3 ± 1.4	65.7 ± 6.8	11.3 ± 1.6	11.3 ± 1.1	–
T. cristatus	–	–	234.6 ± 21.9	45.6 ± 4.8	–	–	–
B. bombina	52.5 ± 4.2	121.1 ± 11.3	386.7 ± 40.9	51.9 ± 5.1	41.9 ± 4.3	–	–
P. fuscus	35.6 ± 3.1	15.4 ± 1.4	6.3 ± 0.5	33.1 ± 2.9	–	–	76.8 ± 4.6
B. bufo	55.5 ± 4.3	51.8 ± 4.8	10.3 ± 1.9	43.7 ± 3.9	45.5 ± 4.4	25.6 ± 2.6	34.6 ± 3.1
B. viridis	29.0 ± 2.8	17.8 ± 2.5	–	–	–	–	–
B. calamita	–	–	–	–	–	–	–
H. arborea	34.5 ± 2.9	12.4 ± 1.0	187.8 ± 16.9	26.7 ± 2.9	23.4 ± 2.1	–	–
R. esculenta complex	345.6 ± 31.5	41.2 ± 3.8	67.9 ± 6..1	29.8 ± 3.6	342.7 ± 31.7	–	–
R. arvalis	178.5 ± 14.6	390.7 ± 35.9	453.7 ± 56.0	564.9 ± 62.9	112.9 ± 9.1	25.7 ± 2.1	67.8 ± 5.9
R. temporaria	–	8.3	–	–	–	–	–
Mean total density	954.9 ± 67.6	658.7 ± 59.0	1361.6 ± 135.8	861.4 ± 78.6	577.7 ± 48.1	62.6 ± 5.8	179.2 ± 20.3

V) low moors;

VI) raised bogs, and

VII) dry pine forests.

There are 8 species of amphibians in the riparian ecosystems. Only the Common Frog and the Natterjack Toad are rare. They are found sporadically throughout Belarus. The Crested Newt is absent. In the population structure of green frogs, with mean density

345.6±31.5 specimens/ha, and also the Moor Frog, 178.5±14.6 specimens/ha, dominate by number. Density of populations of the remaining species occurring there is much lower and does not exceed 55.5 specimens/ha. The total density of amphibian populations in riparian ecosystems is 954.9±67.6 specimens/ha.

The same number of species (8) is typical for natural and slightly modified communities of lowland meadows periodically flooded by high waters. Moor Frog, with a density of 390.7±35.9 specimens/ha, and the Fire-Bellied Toad (121.1±11.3) prevail there; for the remaining species this parameter did not exceed 51.8±4.8 specimens/ha. Common Frogs occur occasionally on lowland meadows but avoid the low and widely overflowed Pripyat floodplain. Here, we can recall that building of polder systems concerned with the dyking promotes maintenance of a stable hydrological regime and growth in number of this species in the floodplain of the Pripyat. Total density of amphibian population on lowland meadows is a little lower than in the riparian zone of basins, 658.7±59.0 specimens/ha.

Species composition of amphibians in floodplain oak woods (gramineous and motley grasses) is 8 species. Optimal conditions are formed there for a majority of them as confirmed by their high numbers. The high mean level of density is indicative for the Moor Frog (453.7±56.0 specimens/ha), the Fire-Bellied Toad (386.7±40.9) and the Crested Newt (234.6±21.9). Density of populations of all other species is much lower. The total density value in this group of ecosystems reaches the maximum level, 1361.6±135.8 specimens/ha. The number of amphibians in oak woods, as well as in other flooded ecosystems, undergoes a strong seasonal and yearly variation connected with regular flood processes and weather fluctuations in spring and summer.

Species diversity of amphibians in alder forests (nettle-grown and sour) includes 8 species. Absolute dominant by number is the Moor Frog (564.9±62.9 specimens/ha). Population density of other species does not exceed 65.7±6.8 specimens/ha. Total density of populations is notably lower than in oak woods: 861.4±78.6 specimens/ha.

Only 6 species of amphibians occur in open low moors. Green frogs (342.7±31.7 specimens/ha) and Moor Frogs (112.9±9.1) are notably dominant. Total density of amphibian populations reaches 577.7±48 specimens/ha.

Communities of raised bogs and dry pine forests, where only 3 species of amphibians were recorded, are most simply organized. Moor Frog (25.7±2.1 specimens/ha) and Common Toad (25.6±2.6) dominate on raised bogs. Mean value of density of amphibian populations for this class of ecosystems was 62.6±5.8 specimens/ha. Dry pine forests (mossy, lichenous, bilberry) in the southern part of the Pripyatsky National Park are also characterized by low-level species diversity and abundance of amphibians. In the composition of biotic communities, the Common Spadefoot (mean population density of 76.8±4.6 specimens/ha) dominates. The most adapted to dry conditions is also the Moor Frog and Common Toad (density of populations 67.8±5.9 and 34.6±3.1 specimens/ha). Total density of amphibian population was 179.2±20.3 specimens/ha.

Thus, the natural landscapes of Pripyatsky National Park have shown that with changes of geomorphological, orographic and geobotanical conditions and, first of all, with the

changes of xerophication of ecosystems, natural restructuring of amphibian populations occur. Their high number (to 1361.6±135.8 specimens/ha) and species combinations suggest that the diversity and abundance of ecological resources, probably, is a more important factor determining the structure of populations than is interspecific competition.

The spatial structure of amphibian complexes in local conditions is apparently determined not only by specific features, characteristics of mutual relations of species and level of competition in communities but also by ecological capacity of environment, trophic supply of habitats, their protective attributes and other parameters of the ecosystems.

4.4. Trophic Structure

In the previous chapters, we described features of structural organization of the assemblages of amphibians in Belarus, spatial variability of species composition and landscape-ecological differentiation of species. Based on analysis of functional organization of different assemblages, it is necessary also to estimate trophic relations of close species. Trophic structure is a fundamental aspect and a major parameter of natural communities (Pianka, 1981; Giller, 1988). The comparative study of trophic spectra in animals allows one to estimate their trophic level and to clarify a position in the trophic network of ecosystems (Petrusenko and Khomenko, 1989; Kuzmin, 1992).

Taxonomic spectrum and composition of food in amphibians of Belarus were described only in few works (Sapozhenkov, 1961; Rodionenko, 1962; Krapivnyi and Kroshchenko, 1964; Pikulik, 1985; etc.). From these publications only general characterization of diet in common species of amphibians was provided. The list of prey objects of particular species has been extended and completed during recent years.

Recently, there is a noticeable shift in ecology and trophology of amphibians to the estimation of functional organization of communities, an intermediate level of organization between populations and ecosystems. The interest to this problem is explained by the fact that at this level reallocation and regulation of matter and energy circuit in ecosystems takes place (Shlyakhtin and Nosova, 1989).

Therefore, the following problems are discussed in this section:

1) estimation of food composition in rare and poorly studied species (*B. calamita, T. cristatus, T. vulgaris, H. arborea, P. fuscus, B. viridis*);

2) clarification of trophic (guild) organization of assemblages, characters of alimentary resources allocation between species, degree of overlap and difference in diets; and

3) general characterization of trophic structure.

As comparative trophological analysis has shown, the amphibians of Belarus includes three tropho-functional groups of species (guilds) distinguished by food composition (taxonomic position and ecological features of food objects):

1) consumers of ground invertebrates (all species after metamorphosis);

2) consumers of algae and decomposing organic matter (Anura during the larval period);

3) consumers of aquatic invertebrates (larvae and adult newts in the aquatic phase).

This classification is schematic enough and incomplete because it does not take into account food composition and some peculiarities of feeding in different guilds (e.g., cannibalism is typical for anuran larvae and adults). Exact differentiation is complicated also by specific substructures of particular guilds.

The diets of amphibians – consumers of ground invertebrates – are represented almost only by arthropods, mainly insects (Table 24). Only in the stomachs of green frogs are conspecific individuals found based on our studies and the literature. The main food resources of this group are ground invertebrates: Formicidae, Aranei, Homoptera, Diptera, Gastropoda, Carabidae and Lepidoptera. Aquatic invertebrates are important for some species (*R. esculenta* complex, *B. bombina*) from nearby water ecosystems.

As shown in Table 24, the spectra of consumed taxonomic groups are more or less similar for the majority of amphibians but shares of particular groups vary considerably by amphibian species. The spectrum of commonly consumed groups, as well as their interrelations in the diets of amphibians of different species, is shown in Fig. 35.

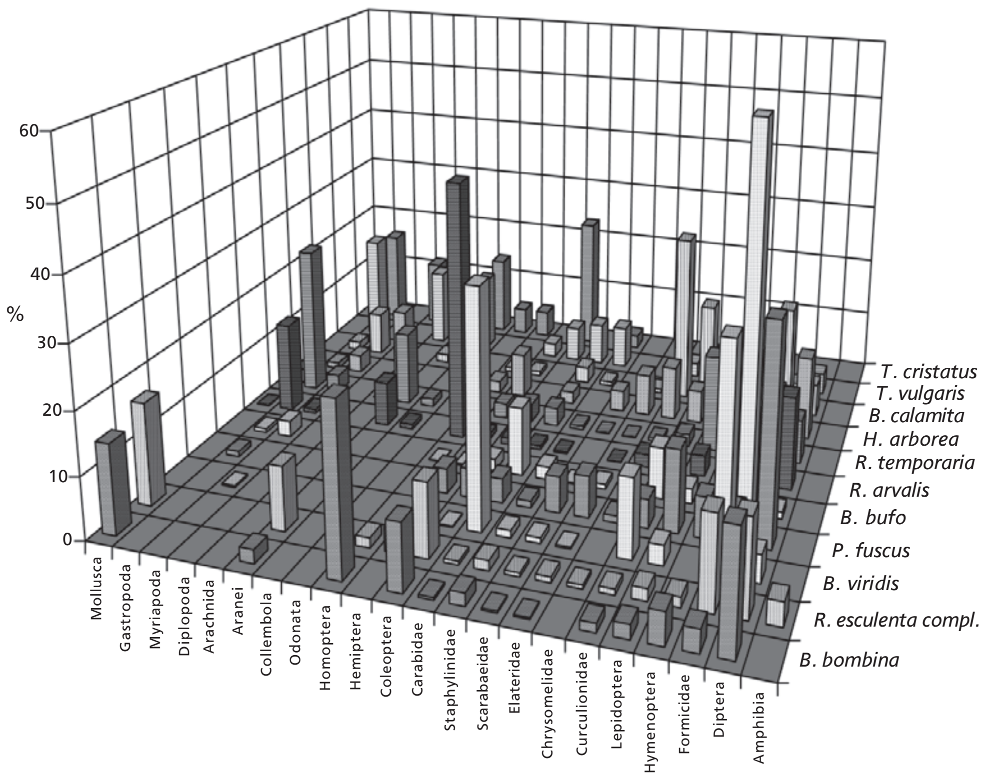


Fig. 35. Trophic differentiation of different species of amphibian based on the taxonomic composition of the diets.

Table 24. Food spectrum of amphibians in terrestrial ecosystems of Belarus.

Prey taxa	Species										
	B. bombina	*R. esculenta* complex	*B. viridis*	*P. fuscus*	*B. bufo*	*R. arvalis*	*R. temporaria*	*H. arborea*	*B. calamita*	*T. vulgaris*	*T. cristatus*
Mollusca	14.4	16.5	–	–	–	0.1	–	–	–	–	
Gastropoda	–	–	–	0.9	0.6	15.1	25.0	1.0	1.4	18.0	16.1
Crustacea	5.7	–	–	–	0.1	0.3	–	–	–	–	–
Isopoda	–	–	–	–	–	–	–	3.5	–	–	–
Myriapoda	–	–	0.3	–	2.6	0.7	3.0	3.0	7.4	–	–
Diplopoda	–	–	–	–	–	0.4	–	–	–	–	11.5
Arachnida	–	–	–	–	1.4	–	0.1	12.4	–	13.3	4.6
Aranei	2.2	10.3	–	4.0	–	7.4	12.4	–	1.4	–	–
Oligochaeta	0.4	–	0.9	–	0.4	–	–	0.5	–	3.6	2.3
Lumbricidae	–	–	–	1.4	–	–	–	–	–	–	–
Collembola	–	–	–	–	–	0.8	1.3	–	–	13.2	13.8
Trichoptera	–	–	–	–	0.1	–	–	1.0	2.0	–	2.3
Odonata	–	8.4	–	–	–	–	–	1.0	–	–	4.6
Zygoptera	–	–	–	–	–	–	–	1.5	–	–	–
Blattoptera	–	0.3	0.2	–	–	–	0.3	2.5	1.4	–	2.3
Homoptera	26.8	1.6	–	–	0.1	43.2	17.0	2.0	0.7	–	4.6
Aphidinea	–	0.6	–	–	0.1	0.8	–	0.5	–	–	–
Cicadellidae	0.1	–	–	–	–	0.3	–	0.5	–	–	–
Hemiptera	–	3.7	0.2	4.0	0.2	1.0	2.5	7.5	0.7	2.4	–
Nabidae	–	–	–	–	–	–	–	–	–	3.6	2.3
Coleoptera	10.6	11.8	0.2	4.7	1.9	1.1	3.1	–	–	6.0	23.0
Carabidae	0.4	0.6	37.5	3.9	11.2	0.6	3.1	2.0	2.7	7.2	–
Hydrophilidae	2.4	1.6	–	–	0.4	–	0.1	–	0.7	–	–
Silphidae	–	–	–	–	–	–	0.2	–	–	3.6	2.3
Ditiscidae	1.8	–	–	–	1.4	–	0.1	–	–	–	–
Staphylinidae	2.0	1.6	1.2	1.1	2.1	0.3	0.6	–	0.7	7.2	2.3
Scarabaeidae	0.3	0.6	0.9	6.0	0.4	–	0.1	3.5	–	–	–
Elateridae	0.3	0.9	0.3	6.7	0.8	0.1	0.1	7.0	0.7	–	–
Byrridae	0.1	–	–	–	0.4	–	–	–	5.4	–	–
Coccinellidae	–	–	0.3	–	0.3	–	0.8	2.0	–	2.4	4.6
Tenebrionidae	–	–	–	0.2	–	–	–	–	–	–	–
Chrysomelidae	–	0.6	–	1.1	0.8	2.1	0.5	9.0	28.4	2.4	–
Curculionidae	1.4	0.9	12.6	4.6	8.3	1.8	2.0	5.5	16.9	–	–
Lepidoptera	2.2	1.9	3.2	13.2	2.4	3.4	15.9	4.5	–	3.6	–
Sphingidae	–	–	–	–	–	–	–	–	–	–	4.6
Hymenoptera	5.0	1.6	–	6.5	0.7	1.7	1.9	2.5	4.1	2.4	–
Ichneumonidae	–	–	0.2	0.2	–	0.3	0.6	–	–	–	–
Formicidae	3.5	14.6	34.8	5.3	61.5	2.5	0.7	7.5	18.2	1.2	–
Diptera	18.6	14.9	4.4	34.5	1.1	15.1	7.3	13.9	5.4	3.6	–
Culicidae	–	0.6	–	–	–	–	–	3.0	–	2.4	–
Syrphidae	–	–	–	0.4	–	–	–	–	–	–	–
Chloropidae	–	–	–	–	–	–	–	2.0	–	2.4	–
Insecta spp.	0.8	1.6	–	0.2	0.1	–	0.2	–	–	–	–
Amphibia	–	3.7	–	–	–	–	–	–	–	–	–
Other	1.0	1.1	2.8	4.7	0.6	0.9	1.1	0.7	1.4	1.5	1.1

To estimate food diversity (i.e., trophic niche breadth), we used the polydominance index (I) calculated from the Simpson formula which, in our opinion, characterizes the heterogeneity or "uniformity" of the composition of the diet (Table 25). According to this ranking in the amphibian species studied by us, it is possible to determine forms with relatively narrow food niche where only 1–2 prey groups occur (I = 0.241–0.401).

Common Toads have the narrowest trophic niche and eat mainly ants (Formicidae; 61.5%). Moor Frog eats mainly Homoptera (43.2%), Gastropoda (15.1%) and Diptera (15.1%). Green Toad feeds mainly on beetles (Carabidae, 37.5%) and ants (Formicidae, 34.81%).

The majority of other amphibians display relatively wide food spectra (I=0.142–0.159). In the food of the Common Spadefoot, Diptera (34.5%) are widely represented, in the Natterjack Toad Chrysomelidae (28.4%), Formicidae (18.2%) and Curculionidae (16.9%), and in the Fire-Bellied Toad Homoptera (26.8%), Diptera (18.6%) and Mollusca (14.4%).

The last group has the most generalized diet, the food composition is characterized by a noticeable homogeneity of preys (I=0.072–0.119). The greatest "uniformity" of food by the proportion of ingested taxonomic groups is typical for the Tree Frog and also for the Smooth and the Crested newts. According to these data, we can suppose that the lowest feeding selectivity is typical for the forms with low mobility.

The diet of different species is similar in general (Table 26). In the Common Frog and the Tree Frog trophic niches overlap significantly (Morisita index I'=0.6) with those of 6 other species. For example, the diet of the Common Frog, includes the same groups as in the Moor and green frogs, Fire-Bellied Toad, Smooth Newt, Spadefoot and Tree Frog.

The large overlap of trophic niches (the same values of I') was found also for the Spadefoot, Moor and Green frogs, each of which consumes taxa that are found in the diet of 5 species of amphibians.

According to these data, the largest overlap of trophic niches is between the Moor Frog and Fire-Bellied Toad (I'=1.897), and also between Smooth and Crested newts (I'=1.421),

Table 25. Food diversity in different amphibian species (by the values of the polydominance index I).

Species	**Parametres**		
	Number of prey specimens	**Number of alimentary groups**	**Polydominance index (I)**
B. bufo	1807	24	0.401
B. viridis	582	22	0.281
R. arvalis	729	22	0.241
B. calamita	148	19	0.159
P. fuscus	571	28	0.152
B. bombina	716	22	0.148
R. esculenta complex	322	24	0.148
R. temporaria	1279	27	0.142
T. cristatus	88	17	0.119
T. vulgaris	166	20	0.092
H. arborea	201	27	0.072

Table 26. Similarity of food taxonomic spectra in different species of amphibians in terrestrial ecosystems of Belarus (by Morisita index I'_l).

Species	*B. bombina*	*P. fuscus*	*B. bufo*	*B. viridis*	*B. calamita*	*H. arborea*	*R. esculenta* complex	*R. arvalis*	*R. temporaria*	*T. vulgaris*	*T. cristatus*
B. bombina	–	1.009	0.371	0.315	0.299	0.471	0.987	1.897	0.893	0.221	0.472
P. fuscus	–	–	0.583	0.682	0.521	0.831	0.877	0.763	0.696	0.339	0.150
B. bufo	–	–	–	1.307	0.656	0.292	0.469	0.108	0.068	0.112	0.033
B. viridis	–	–	–	–	0.670	0.337	0.426	0.145	0.173	0.243	0.008
B. calamita	–	–	–	–	–	0.737	0.489	0.352	0.247	0.206	0.044
H. arborea	–	–	–	–	–	–	0.959	0.957	0.726	0.826	0.259
R. esculenta complex	–	–	–	–	–	–	–	0.750	0.614	0.310	0.577
R. arvalis	–	–	–	–	–	–	–	–	1.107	0.301	0.385
R. temporaria	–	–	–	–	–	–	–	–	–	0.807	0.198
T. vulgaris										–	1.421
T. cristatus											–

Common and Green toads (*I'*=1.307), Moor and Common frogs (*I'*=1.107), Fire-Bellied Toad and Spadefoot (*I'*=1.009).

The complex estimation of the trophic structure of guilds allows us to assume that the core of trophic structure of amphibian assemblages of terrestrial ecosystems consists of 6 species (*R. temporaria, H. arborea, R. arvalis, R. esculenta* complex, *P. fuscus, B. bombina*) whose trophic niches overlap significantly. The remaining 5 species (*T. vulgaris, T. cristatus, B. bufo, B. calamita, B. viridis*) occupy marginal areas of the ecological space, and their diet is notably different taxonomically.

It is necessary to note that the results of the analysis of trophic niches in the guild of amphibians in terrestrial ecosystems is based on combined samples taken from the territory of Belarus in different geographical localities and ecosystems and in different years and seasons. There are considerable local differences in feeding of separate species caused by natural zonality, habitat differences, seasonal and long-term dynamics of faunistic composition of invertebrates and other causes. The results of an estimation of similarity in composition of food in several species of amphibians jointly living in one habitat indicate that the degree of their overlap and, therefore, level of trophic competition, can differ considerably from the common scheme. In most cases the feeding of several syntopic species was even more similar.

It is also necessary to note, that a comprehensive approach including analysis of a size composition of prey, analysis of spatial overlap by localities, data on temporary and microhabitat distribution of different species during feeding and other aspects of trophology is necessary for a comprehensive description of trophic structure and a correct estimation of the feeding relations between different components of the assemblages.

Chapter 5.
PHENOTYPIC VARIABILITY OF POPULATIONS

The study of infraspecific variability of living organisms is one of the major problems of population biology (Schwarz, 1980; Yablokov, 1987). Analysis of variability in natural populations in different parts of a species' range allows an estimation of adaptive possibilities of the species, its spatial structure that reveals landscape features of importance and major factors affecting population dynamics in natural and anthropogenic ecosystems.

Populations of many amphibian species in the temperate zone of Europe are characterized by marked polymorphisms. High phenotypic variability, wide distributions in various ecosystems and high population densities make this group a convenient subject for "medium scale" studies and an analysis of the influence of natural zonation and landscape differentiation on variability of population morphological structure.

5.1. Intraspecific Variability of Morphometric Characters of the Moor and the Common Frogs

The infrapopulation variability in the Moor and the Common frogs was studied on 14 external morphological characters and 12 indices calculated from them. In both species of brown frogs, sexual differences are manifested in a few characters and, first of all, in the proportions of the hind leg L/T, F/T and L/(F+T). However, these differences were found only at a statistical level and not in all population samples (Table 27). In the Moor Frog such differences are displayed in a large majority of population samples and more frequently in southern regions of the Republic.

In the Common Frog, the sexual differences are also detected only at a statistical level and only in 2 of 12 indices, as well as in the body length. The differences were in fewer samples in comparison with the Moor Frog, and with greater frequency occurred in northern Belarus.

Data on the degree of sexual dimorphism allowed us to make the following conclusions. Differences between males and females of the Common and the Moor Frogs in populations from Belarus are displayed only in the proportions of the hind leg, such as L/(F+T), F/T and L/T. Males of both species are characterized by a greater relative hind leg length. Frequency of sexual dimorphism is clearly proportional to the latitude of a site. Both species display differently directed geographical tendencies in the sexual dimorphism. In

Table 27. Frequency of sexual dimorphism exhibiting in population samples of *Rana arvalis* and *R. temporaria* on the territory of Belarus.

Landscape provinces of Belarus	*R. arvalis* Number of samples taken	*R. arvalis* Number of population samples with detected sexual dimorphism,% L/T	F/T	L/(F+T)	*R. temporaria* Number of samples taken	*R. temporaria* Number of population samples with detected sexual dimorphism,% L/T	L/(F + T)
1. Northern Poozerie province	8	62.5	0	37.5	10	40.0	50.0
2. Belorussian Elevated + Fore-Polesie + Central – East – Belorussian provinces	8	50.0	25.0	62.5	17	17.6	17.6
3. Southern Polesie province	15	100.0	13.3	80.0	3	0	0
4. Belarus in general	31	77.4	12.9	64.5	30	23.3	26.7
Value of indices	females	1.93 – 1.97	0.92 – 0.94	1.00 – 1.03	1.86 – 1.97	–	0.97 – 1.04
	males	1.85 – 1.89	0.89 – 0.92	0.97 – 1.01	1.75 – 1.88	–	0.92 – 0.99

the Moor Frog, the expression of sexual dimorphism increases from north to south, whereas in the Common Frog it decreases in the same direction.

As the sexual differences are characteristic only in small number of indices, further analysis of the degree of infrapopulational variability of all characters (14) and indices (12) in the both species was conducted on samples represented by animals of both sexes (Table 28). In both species the same characters are highly variable, such as eye length (L.o), tympanic membrane length (L.tym), first toe length (D.p) and inner metatarsal tubercle length (C.int). The degree of variability of these indices that reflect proportions of frogs body is quite different. In the indexed variant the component of correlation of particular characters with the size of animals is retracted. Maximum variability is typical for the proportions describing relative eye length (L.c/L.o, D.r.o/L.o), tympanic membrane (L.o/L.tym), inner metatarsal tubercle (D.p/C.int, T/C.int) and snout width (Sp.o/D.r.o). Coefficients of variation of these characters and proportions for both species strongly varies in samples from different populations, but in usually the values mostly exceed those for characters and proportions describing relative length of the head (L/L.c) and snout (L.c/D.r.o), as well as relative head width (L.c/Lt.c).

The proportions of the hind leg F/T, L/T and L/(F+T) have the narrowest range of infrapopulational variability. This indicate that common tendencies of variability in the both species generally coincide, as revealed from unidirectional character variability of the whole spectrum of analyzed characters. The degree of infrapopulational variability of particular characters is determined in different ways.

Table 28. Variation coefficients of morphological characters in samples from different populations of the *Rana arvalis* and *R. temporaria* on the territory of Belarus.

Characters, indices	*R. arvalis* (50 samples)		*R. temporaria* (45 samples)	
	lim CV,%	M±m,%	lim CV,%	M±m,%
L	5.2 –14.1	8.43 ± 0.294	6.8 – 12.0	11.0 ± 0.379
L.c	6.6 – 10.7	7.80 ± 0.263	6.4 – 9.9	9.75 ± 0.365
L.t.c	8.9 – 11.4	8.86 ± 0.285	7.3 – 12.5	11.31 ± 0.388
D.r.o	6.8 – 9.1	8.21 ± 0.242	6.5 – 10. 4	9.86 ± 0.388
L.o	10.8 –13.7	11.59 ± 0.330	11.1 –15.6	13.69 ± 0.447
L.tym	11.2 –20.9	13.18 ±0.430	14.6 – 24.1	19.91 ± 0.655
Sp.oc	8.7 – 12.2	9.30 ± 0.442	7.2 – 13.3	11.21 ±0.432
F	8.5 – 13.0	10.06± 0. 354	7.5 – 13.4	11.82 ± 0.397
T	7.2 – 11.2	9.51 ± 0.271	7.4 – 11.1	9.64 ± 0.411
D.p	9.3 – 15.9	11.60 ± 0.362	9.4 – 13.9	12.36 ±0.383
C.int	10.9 – 15.5	12.46 ± 0.369	12.2 – 17.9	14.92 ± 0.481
L/L.c	3.7 – 5.5	4.46 ± 0.184	3.0 – 4.7	3.75 ± 0.139
L.c/L.t.c	3.9 – 7.3	4.73 ± 0.264	3.3 – 4.6	3.77 ± 0.164
L.c/L.o	9.8 – 14.0	10.40 ± 0.460	9.1 – 10.7	8.74 ± 0.254
L.o/L.tym	12.0 – 17.6	13.40 ± 0.540	12.2 –18.2	14.69 ± 0.589
L.c/D.r.o	5.1 – 7.7	5.40 ± 0.252	3.7 – 4.8	4.48 ± 0.149
D.r.o/L.o	10.6 – 13.8	11.25 ± 0.381	9.0 – 11.3	9.98 ± 0.445
Sp.o/D.r.o	6.6 – 9.6	7.19 ± 0.290	5.7 – 8.8	7.42 ± 0.313
D.p/C.int	10.8 – 15.7	11.76 ± 0.480	9.5 – 15.5	11.30 ± 0.457
L/T	3.8 – 6.4	5.08 ± 0. 291	3.6 – 4.7	4.65 ± 0.286
F/T	3.6 – 5.4	4.09 ± 0.139	2.8 – 6.4	4.48 ± 0.457
L/(F+T)	3.8 – 5.3	4.30 ± 0.166	3.0 – 4.9	4.16 ± 0.194
T/C.int	8.2 – 11.5	9.85 ± 0.423	8.1 – 11.8	9.68 ±0.381

First, it can be substantially determined both by age differences of the individuals in the samples, individual variability in growth rate of the same age classes in different ecosystems, and by variability of individuals from different generations, growth of which have grown up in different environmental conditions in previous years. In addition, the degree of infrapopulational variability is influenced by selective pressure, more exactly, stabilizing selection that determines the differential stability of the forms of development (Schmalhauzen, 1969).

This is evident from the low variability of such conservative parameters as the proportions of the hind leg and increased variability of the proportions D.p/C.int and T/C.int that reflect relative size of the inner metatarsal tubercle. These results corresponds well with published data on postmetamorphic growth rate in different geographical populations of these species (Ishchenko, 1993; Pyastolova and Ivanova, 1979; Taraszczuk, 1984; Lada, 1993; etc.). The majority of these authors studied variability of hind leg proportions only. We found that the proportions of the head also have significant geographical variability, and from the point of view of infrapopulational regulation their variability is under very rigid stabilizing selection.

5.2. Interpopulation Variability of Morphometric Characters of the Moor and the Common Frogs

Analysis of interpopulation variability of the body length and 12 proportions of the Moor and the Common frogs showed that the main tendencies in both species coincide.

Data from the Table 28 demonstrate that both species of brown frogs have very wide amplitude of absolute values of proportions and mean population values that reflect variability of these parameters in 50 population samples of the Moor and 45 of the Common Frogs. Spectra of characters with high variability almost coincide in both species. These are proportions L/T, F/T, L/(F+T), D.p/C.int, T/C.int, L.c/L.o, D.r.o/L.o, L.c/D.r.o (also Sp.o/D.r.o for the Moor Frog, and L/L.c for the Common Frog). The degree and trend of interpopulation variability of each of these characters differ in these species. The only shared trait is that the most essential differences in values of large majority of these proportions are specific to population series of the Moor and the Common frogs collected from ecosystems of the same type and from different ecosystems in various landscape provinces of Belarus.

Our data indicate an obvious dependence of the degree of variation of the studied characters of the Moor Frog and the Common Frog on landscape differentiation of the territory.

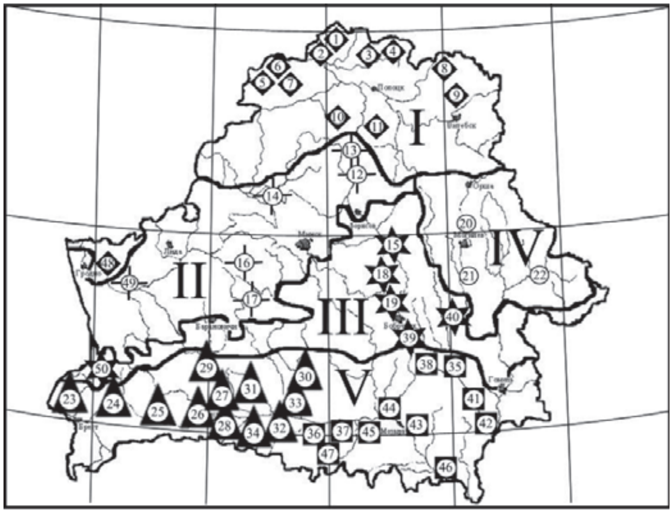
Different living conditions in different localities of Belarus produce significant consequences in the variability of particular characters of brown frogs. In this connection, the tendencies of their variability are not equal. There is a relatively high variation in the proportions L/L.c, L.c/D.r.o, L.c/L.o and D.r.o/L.o in the Moor Frog and the Common Frog within small fragments of their geographical ranges.

The decrease of mean values of the indices L/L.c (3.20–3.14) and L.c/D.r.o (2.39–2.32) and the increase of L.c/L.o (3.64–4.06) and D.r.o/L.o (1.52–1.92) were observed in the Moor Frog north to south. For the Common Frog, in the same direction the increase of values L.c/L.o (3.91–4.12) and D.r.o/L.o (1.69–1.81) was detected. Common Frogs from Poozerie and East-Byelorussian landscape provinces (i.e., northern and northeastern parts of the Republic) are characterized by higher values of the index L/L.c (3.42–3.43 vs. 3.34–3.38) in comparison with other localities.

To understand which characters play the main role in the interpopulation differentiation of frogs in Belarus, multivariate analysis of the whole variability spectrum of absolute parameters and derived indices was conducted with the main components method. The application of this approach allowed us to determine complexes of characters playing the primary roles in differentiation of particular populations and to propose a hypothesis on the cause-and-effect conditionality of such differentiation. The procedure and data of the study of infraspecific differentiation of the Moor Frog by this method was described earlier (Kosova et al., 1992; Galaktionov et al., 1995; Kosova, 1996). Here we propose the

results of comparative analysis of variability of both species of brown frogs detected in the space of the 2nd and the 3rd main components in more detail.

Fig. 36 shows the geographical distribution of sampling from populations in the both frog species within the limits of five landscape provinces. The data of these figures indicate



1. - limits of landscape provinces
2. 1-50 - number of population sample
3. Landscape provinces: I - Poozerie (- Vitebsk region.); II - Belorussian eminence (- Gordno region); III - Fore-Polessie (- Minsk region); IV - East-Belorussian (- Mogilyov region); V - Polessie (- Brest region., - Gomel region)

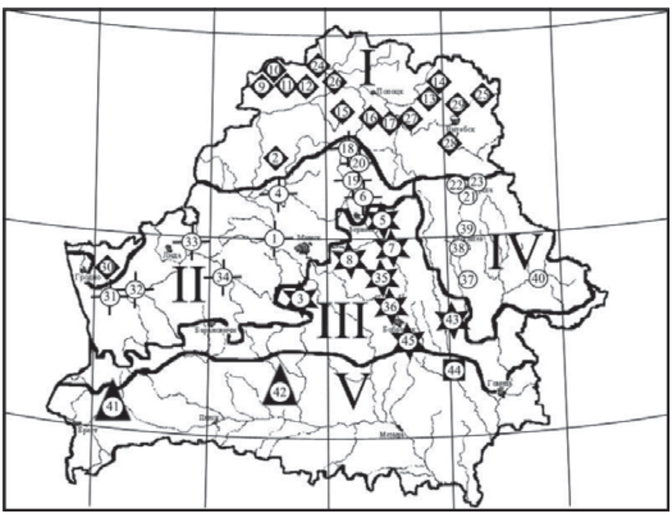


Fig. 36. Geographical distribution of (A) *Rana arvalis* and (B) *Rana temporaria*.

that both for the Moor and the Common frog in the space of the 2nd and the 3rd main components the legible spatial groups of population samples were separated. In these groups, the differentiation of populations that belong to floodplain zones of different large river basins of the Republic is detected.

What characters are concerned by such differentiation of population samples? The answer is shown from Fig. 37. In the figures indicating the allocation of population samples in the space of the main components, the distance between samples positioned closer to the point of origin is a measure of their morphological similarity. For characters in spaces of the eigenvectors this is not the case because the geometrical equivalent of connection between characters and their eigenvectors is an angle between them. Therefore, the real relationship between characters can be found only in locating points – characters on the surface of a multidimensional sphere. The location of the characters on the plane formed by eigenvectors is a result of their projections from a surface of the sphere on this plane. Therefore, the closer to the point of origin, the less adequately spatial location of points on a plane transmits the geometrical attitudes between the conforming characters. On one hand, contributions of characters are the coordinates of points on this plane, on the other, they are proportional to the correlation coefficients of characters with the eigenvectors. The closer that the characters are positioned to the point of origin, the less they correlate with each other and participate in the structure of eigenvectors.

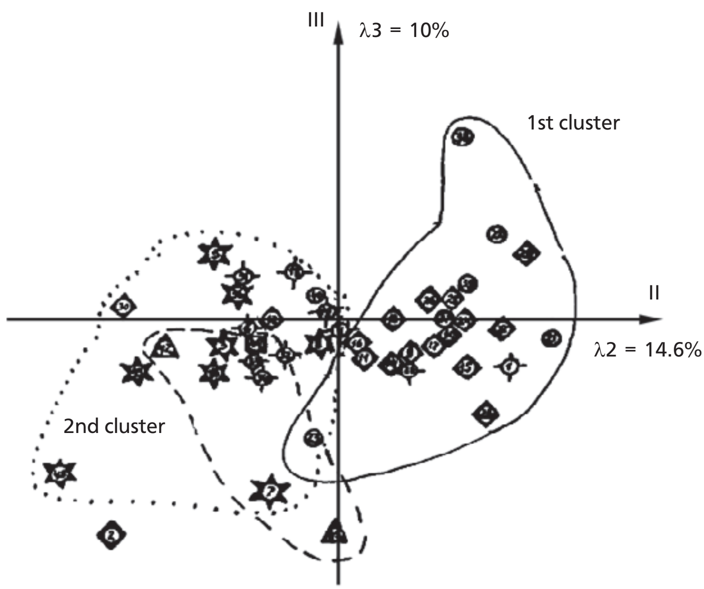


Fig. 37. Allocation of population samples of *Rana temporaria* in the space of II and III main components based on morphometric characters.
See Fig. 36 for localities; solid line = samples from Poozerie province; dotted line = the same from Polesie province; points = the same from Fore-Polesie and Elevated-Belorussian provinces.

The data on Fig. 37 clearly demonstrate that the cluster generating the 2nd eigenvector includes the proportions L.c/L.o, D.r.o/L.o, L.c/D.r.o, L/T, F/T, L/(F+T), characters L.tym and L.o, despite the fact that they are positioned ob different sides. This cluster determines the differentiation of samples in the space of the 2nd main component. The proportions L.c/D.r.o, L/T, F/T and L/(F+T) increase, and L.c/L.o and D.r.o/L.o decrease in the direction of this component. In the same way, the increase of proportions Sp.o/D.r.o, L.o/L.tym, L.c/L.o, D.r.o/L.o, L/T, F/T, L/(F+T) and the decrease of L.c/Lt.c, L./L.c, T/C.int, D.p/C.int in the direction of the 3rd main component can be seen. Frogs populations in the "center" group (from the more elevated part of the Republic) vary simultaneously by two main components and in the opposite directions.

Thus, such proportions as L.c/L.o, L.c/D.r.o and D.r.o/L.o determine the main differences between populations in the space of the 2nd main component. These proportions have divided all population groups of the Moor Frog from the north and the south of the Republic (i.e., from Poozerie and Polesie landscape provinces) and most significantly separated them in the space of the 2nd main component.

The proportions of the hind leg, such as L/T, L/(F+T), F/T, D.p/C.int and T/C.int, play a very important role in the differentiation of populations in the space of 3rd main component. These proportions form the main cluster of the characters that determine differentiation of population groups of this species that occupy the floodplains of the largest rivers. Populations from northern regions of the Republic (basin of the Zapadnaya Dvina River) differ significantly ($p<0.05$) from populations in the basin of the Pripyat River (Polesie province) by large mean population values of the characters L.o, L.tym, proportion L.c/D.r.o and, at a smaller extent, D.r.o/L.o, L.c/L.o, S.p.o/D.r.o, and are characterized by an identical range variability of hind leg proportions. The populations in the floodplains of the rivers of Dnieper and Berezina in the eastern part of the Polesie province differ from populations in the floodplain of the river Pripyat (Polesie province) and Zapadnaya Dvina (Poozerie province) by having longer hind legs (greater values of the proportions T/C.int, D.p/C.int and smaller L/T, F/T and L/F+T). Moor Frogs of Berezina and Dnieper floodplains are notable in having the greatest hind leg length. The shortest hind legs were from specimens from populations near Losvido Lake situated in the north of Poozerie province.

The main parameters combining population groups of the Moor Frog in isolated clusters in the space of the 2nd main component are, apparently, such abiotic factors as temperature and air humidity. This is especially clear for differentiation of population in the floodplain of the Berezina River that crosses all three landscape provinces in the meridian direction: Elevated Byelorussian, Fore-Polesie and the eastern part of Polesie. The cold, wet climate in the upper parts of the river is replaced by arid, warm in the lower reaches. In the space of the 2nd main component, groups of frogs from the Elevated Byelorussian province, that show the greatest similarity with samples from Poozerie province, and groups from Fore-Polesie

province differ to the maximum. In the space of the 3rd main component the greatest differences from all remaining groups are found in populations of the river floodplain from the eastern part of Polesie province. For the frogs from Fore-Polesie province, the maximum length of the hind leg, minimal dimensions of the inner metatarsal tubercle, smaller values for the lengths of the eye and the tympanic membrane, proportion L.c/D.r.o, and greater values for the proportions L.c/L.o, D.r.o/L.o occur in comparison with populations of this species from the floodplain of Berezina on the territory of the Elevated Byelorussian province.

Our data indicate an infraspecific variability of the main diagnostic characters of the Moor Frog. The indices L/T, F/T, T/C.int and D.p/C.int are subject to significant variation, which are caused by different living conditions of animals in different parts of the Republic. Variation of head proportions is greater, probably, during larval development, and the variation of hind leg proportions, probably, is determined to a greater extent by the features of postmetamorphic growth of the animals. In any case, for the Moor Frogs of the Byelorussian populations the presence of individuals with relatively long legs (L/T = 1.74–1.89 F/T = 0.87–0.95; L/(F+T) = 0.93–1.02; T/C.int = 11.26–12.32) is clear, as well as others that have relatively short legs (L/T = 1.89–2.10; F/T = 0.95–0.98; L/(F+T) = 1.00–1.07; T/C.int = 6.58–9.00).

As to variability of the Common Frog, the main clusters of population groups in the space of the 2nd and the 3rd main components look absolutely different. The figure demonstrates that in the space of the 2nd main component the two groups are clearly distinguished. These are samples from northern Poozerie and from all other landscape provinces. The main clusters of the characters, which differentiate populations, are L.c/L.o, D.r.o/L.o, L/L.c and L.c/D.r.o. These clusters of characters play the main role in differentiation of animals in the space of the 2nd main component. Common Frogs in the Poozerie landscape province differ reliably from all others by having greater values of the characters L.o, L.tym, proportions L/L.c, L.c/D.r.o, smaller values of L.c/L.o, D.r.o/L.o, shorter hind legs, and larger inner metatarsal tubercles.

In the space of the 3rd main component the exact differentiation of population samples was determined by the characters D.p/C.int, T/C.int, L/(F+T) and L/T. In the space of the 3rd main component population groups from the rivers Berezina, Dnieper and Neman are the most separate. Larger values of proportions T/C.int, D.p/C.int and smaller of L/T, F/T, L/(F+T) are specific for populations from the Pripyat River (mouth of the Lan River) and Mukhavets floodplains as compared with populations of the Dnieper floodplain. Among populations distributed on the territory of Fore Polesie province and defined by the most variation of hind leg proportions, individuals from populations from the Berezina floodplain differ by maximum leg lengths. The frogs of these populations differ more significantly by the characters L.o, L.tym and the proportions L.c/L.o and D.r.o/L.o than those of all other populations from this floodplain. Populations from the Berezina floodplain on the territory of the Elevated Byelorussian province are relatively uniform in their morphometric structure. The proportions of the hind leg are more similar to individuals

from populations from the floodplains of the rivers Neman and Zapadnaya Dvina than to those from populations from the floodplain of these rivers on the territory of Fore-Polesie landscape province. Minimal hind leg length is characteristic for the frogs from the floodplain of the Dnieper in the East-Byelorussian province. They also differ by a larger size of the inner metatarsal tubercle, larger values of the characters L.o, L.tym, and the proportion L/L.c, smaller D.r.o/L.o and L.c/L.o. Similarity of morphometric structure is typical for different populations distributed in the floodplain of the Neman River. Frogs from these populations differ from those from the floodplains of the Zapadnaya Dvina (Poozerie province) and the Dnieper (East-Byelorussian province) by smaller values of the characters L.o, L.tym, proportions L/L.c, L.c/D.r.o, larger values of the proportions L.c/L.o, D.r.o/L.o, longer hind legs. Comparaed with populations of the Mukhavets and Pripyat floodplains in the Polesie province, they have shorter hind legs.

We conclude that the same sets of characters (i.e., proportions of fore- and hind legs) are important in differentiating populations of these two sympatric brown frogs species in the space of the 2nd and the 3rd main components. Apparently, this is influenced by climatic zones (in particular, change of temperature regimes from southwest to northeast) and is connected with ecological differences of the Moor and the Common frogs. It indicates, first of all, their different requirements to temperature and humidity. These two abiotic factors play leading roles in the formation of the ecological structure of the brown frogs populations in Belarus (interrelationships of the numbers of these species in ecosystems of river valleys) and in the population number. These factors regulate breeding of frogs, duration and rate of larval development, and timing of metamorphosis when the primary formation of the proportions takes place. Different factors (e.g., food supply, population density) affect growth rate of the animals in future development.

The existence of populations of individuals with relatively long hind legs is a component of variability of the Moor Frog in Belarus. This may indicate a dubious taxonomic status of long-legged subspecies, *R. arvalis wolterstorffi* Fejervary, 1919 from central Europe.

5.3. Analysis of Variability of Phenotypic Structure of the Moor and the Common Frog Populations

As in other parts of the distribution area, polymorphisms of pattern in both species of brown frogs inhabiting Belarus is manifested in the same characters: back spots, pale mid-dorsal stripe, shape and presence of a chevron-shaped occipital and temporal spots, pigmentation of throat and belly, and the structure of the dorsal skin.

The following variants are typical for the Moor Frog. Striata (S) – a pale stripe extends through the middle part of the back and divides it into two symmetric parts. The stripe extends to the extremity of the snout. Individuals with such a phenotype occur only in

the basin of the Pripyat River, and its distribution is clinal (Pikulik, 1985; Kosova 1996; based on 4870 specimens from 62 sites in Belarus). In particular, in some populations the stripe is unclear and reaches only the middle of the head. Such phenotype is designated as hemistriata (hS).

The presence, configuration and sizes of dark spots on the dorsum determine all other variants of dorsal patterns. There are the following phenotypes in the Moor Frog. Maculata (M) – the number of spots is usually insignificant (10–12) but they have rather clear outlines and large sizes, 3–5 mm. Hemimaculata (hM) – spots are present at a very small number (2–5) and their outlines can be less clearly expressed. Punctata (P) – leopard pattern – the number of spots is very large but they are small, fancifully-shaped, cover the entire dorsum of the body as a continuous pattern. Hemipunctata (hP) – very small spots look like dark dots and are present in small number. Burnsi (B) variants lack a slotted pattern. Variants of papillosity of the dorsal skin – Rugosa (R) – the phenotype of papillosity is present. Also there is a variant when it is absent. Phenotypes of the throat and the belly pigmentation include several cases. Nigricollis (NC) and nigriventris (NV) – throat and belly are covered with a large number of dark spots, and albicollis (AC) and albiventris (AV) – pigmentation is absent. The chevron-shaped occipital spot is variable and at least 16 variants are distinguished. Two of them are landscape-dependent: (V+) or (V–), when the spots are present or absent.

The phenotype of an individual represents different combinations of separate phenotypes. For example, numerous Moor Frogs in the basin of the Pripyat River have spots that form 2 continuous dark stripes extending parallel with the mid-dorsal stripe. The phenotype of such individual is designated as SM. In other regions we have collected frogs with different combinations of phenotypes (Table 29).

Some features of the back, throat and belly pattern polymorphisms are characteristic for an individual. It concerns, first of all, expression of a pale mid-dorsal stripe (striata). It is clearly expressed in the Moor Frog, and the border between the stripe and the background is very contrasty. It is expressed faintly in the Common Frog, and the transition to the main background is smooth. Striata is distributed among brown frogs and some other species of anurans (Ishchenko, 1978). The genetic nature of this pale stripe has been studied (Shchupak, 1985; Shchupak and Ishchenko, 1981).

Our studies were conducted on many specimens (2559 specimens, 45 populations) covering all of Belarus. Common Frogs with phenotypes albipunctata, hemialbipunctata (Lebedinsky et al. 1989; Lebedinsky, 1989, 1990) and kandiyohi (Khmelevskaya, 1985) are absent. The spectrum of detected phenotypes in the Byelorussian populations of Moor and Common frogs is shown in the Table 29.

The analysis of phenotypic structure variability in Moor and Common frogs populations conducted by frequencies of 20 phenotypes shows that 12 of them are landscape-dependent. Many populations from the territory of all landscape provinces are characterized by specificity of their phenotypic structure. The data on landscape-typological variability in

Table 29. Phenetic variants of back pattern in *Rana arvalis* and *R. temporaria* from the territory of Belarus.

Phenotype	*R. arvalis*	*R. temporaria*
M	+	+
Hm	+	+
B	+	+
MR	+	+
HmR	+	+
BR	+	+
P	+	+
hmP	+	–
MS	+	–
hmS	+	+
BS	+	–
PS	+	–
hpS	+	–
MRS	+	–
hmRS	+	–
BRS	+	–
PR	+	+
hpR	+	+
hmRP	+	–
hmhpS	+	–
Hp	+	+
hmhp	+	+
Mhp	+	+

Note: M – maculata, hm – hemimaculata, B – burnsi, P – hunctata, hp – hemipunctata, R – rugosa, S – striata.

the Moor Frog phenotypes and landscape-geographical variation of variability in Belarus are shown in Table 30.

This table show that frequency of striata in the Byelorussian populations of the Moor Frog varies within 0–38.7%. The zone of this phenotype is limited by Polesie Lowland and the basin of the Pripyat River. Its frequency is maximum in Pinskii District (37.3–38.7%) and is characterized by clinal variation directed down- and upstream of the Pripyat. In populations occupying the floodplains of the Dnieper, striata is absent, while in Ukraine (Ishchenko, 1978) in the floodplain of the same river near Kiev City its concentration reaches 5.1% and is characterized by considerable interpopulation variability (6.5–81.8%). The distribution of striata in Belarus displays a clear contingency with landscape differentiation. The northern limit of distribution of the Moor Frog populations with striata coincides substantially with the northern limit of Polesie landscape province.

In the zone of this phenotype, *R. temporaria* is almost absent, while in other landscape provinces, where this phenotype is absent in the Moor Frog, the Common Frog number ares comparable to those of another species or exceeds it (up to 100%). This was observed in the central part of the Republic (Pikulik, 1985). It is known that tadpoles of the Common

Table 30. Variability of phene concentrations in *Rana arvalis* from different landscape provinces of Belarus.

Provinces	Characters	Phene frequencies,%								
		S	M	P	B	R	NC	NV	V+	V–
I(n=12)	Min-max	0	19.7-47.0	1.2 – 33.3	4.8 – 55.8	2.5 – 84.6	4.5 – 51.5	1.5 – 50.0	9.5 – 44.8	7.6 –73.1
	M±m		37.8±01.89	37.8±1.89	16.0±2.89	20.3 ±4.05	37.0±1.75	27.0 ±2.61	28.0 ±3.44	38.4 ±3.46
II(n=6)	Min-max	0	28.5-45.3	1.0 - 14.2	26.9 – 42.1	6.6 – 37.3	0 – 28.4	0 – 44.8	0 – 41.8	18.2 – 60.0
	M±m		36.12± 2.49	7.45 ±2.1	30.88±2.28	19.59 ±5.6	12.15 ±3.8	17.88±:6.1	29.0 ± 6.5	33.6 ±7.26
III(n=6)	Min-max	0	26.4 – 43.8	2.2 –15.1	15.7 –53.3	0 –50.7	0 –8.3	0 –15.1	25.0 – 50.6	7.5 – 35.6
	M±m		32.37±3.01	6.78±1.90	32.27±3.79	25.23±7.51	3.6±1.26	7.40±3.04	33.8±3.66	21.4±2.96
IV(n=3)	Min-max	0	33.6 – 45.0	11.6 –14.5	11.8 – 45.0	8.0 –32.5	0 – 15.0	1.3 – 17.0	15.8 – 49.1	17.8 – 25.0
	M±m		40.3 ±5.4	12.9 ±0.42	23.1 ±10.5	20.07 ±1.22	7.67 ± 4.34	8.77 ±4.55	27.5±10.8	20.9±1.13
V(n=23)	min–max	0 – 38.7	12.3 – 53.3	0 – 22.2	3.3 – 37.2	2.5 – 25.9	0 – 23.3	0 – 15.2	16.7 – 51.6	7.5 – 43.5
	M±m	10.7 –2.56	40.8 ±2.18	7.49 ±1.07	16.88 ±2.05	13.80 ±1.49	9.22 ±1.21	6.03 ±0.85	32.1±13.8	19.8±2.01

Note: Provinces: I – Poozerie, II – Belorussian Elevation, III – Fore-Polesie, IV – East-Belorussian, V – Polesie; n – number of samples.

Table 31. Variability of phene concentrations in *Rana temporaria* from different landscape provinces of Belarus.

Provinces	Parameters	Phene frequencies, %									
		S	hS	M	P	B	R	V+	V–	AV	AC
I (n=17)	Min – max	0 – 9.0	4.9 – 40.0	16.7 – 60.0	0 – 1.7	0 – 14.6	12.0 – 82.7	40.0 – 71.4	0 – 16.0	0 – 33.3	0 – 38.8
	M±m	4.2 ± 0.74	16.8 ± 2.18	34.6 ± 33.0	0	5.2 – 1.20	50.6 ± 4.73	53.9±2.50	6.9 ±1.09	12.2±3.07	27.7 ± 2.62
II(n=10)	Min – max	0 – 19.1	14.0 – 35.7	10.3 – 63.2	0 – 1.6	0 – 14.7	31.9 – 84.6	46.2 – 71.4	3.3 – 15.4	0 – 46.7	0 – 69.1
	M±m	11.0 ± 0.95	22.4 ± 2.24	31.5 ± 4.8	0	6.7 ± 0.65	50.6 ± 0.30	60.5 ± 0.13	7.2 ±0.48	16.5±13.9	34.2 ± 0.70
III(n=8)	Min – max	1.2 – 22.2	3.2 – 23.1	0 – 46.0	0 – 2.1	0 – 12.5	37.0 – 64.9	53.1 – 70.0	0 – 7.9	3.1 – 62.5	13.0 – 100
	M±m	9.6 ± 2.43	11.5 ± 0.6	32.9 ± 3.52	0 – 2.1	0 – 12.5	37.0 – 64.9	53.1 – 70.0	0 – 7.9	3.1 – 62.5	13.0 – 100
IV(n=7)	Min – max	5.0 – 15.3	9.5 – 27.1	33.3 – 51.3	0	1.4 – 16.7	27.8 – 73.2	11.1 – 63.4	4.2 – 27.8	0 – 33.4	6.0 – 66.7
	M±m	9.1 ± 1.58	18.4 ± 2.65	40.1±1.46	0	5.7 ± 1.96	58.1 ± 6.43	43.9±5.78	10.6±3.12	13.8±4.68	30.6 ± 7.28
V(n=3)	Min – max	0 – 9.5	0 – 30.8	7.4 – 17.6	0	0 – 6.6	42.2 – 72.2	23.5 – 71.9	2.8 – 5.9	0 – 66.9	11.1 – 35.3
	M±m	4.9 ± 2.75	21.0 ± 6.5	13.9 ± 1.86	0	4.17 ± 2.09	59.7 ± 4.57	42.9 ± 14.8	4.8±1.01	28.2±20.1	25.9±6.80

Provinces: I – Poozerie. II – Elevated Belorussian. III – Fore-Polesie. IV – East-Belorussian. V – Polesie province; n – amount of population samples

Frog produce an inhibiting effect on the growth, development, and number of those in the Moor Frog, and the effect of inhibition may cause the decrease of the frequency of striata among metamorphs (Pikulik, 1976). This effect also was found with increasing tadpole density in the Moor Frog.

According to Table 30, concentrations of the three remaining phenotypes of dorsal patterns of the Moor Frog vary considerably by landscapes. Maculata varies in Poozerie and Polesie provinces most significantly.

A considerable variability is typical also for punctata. The maximum frequency of this phenotype occurs in populations from Poozerie province where it occurs at 10.0–33.3%. Only in two population samples from Verkhnedvinskii and one from Braslavskii districts were the frequencies of this phenotype minimal (1.2; 7.5 and 8%, respectively).

Occurrences of burnsi in populations from different provinces also are unclear. The most essential fluctuations were observed in the samples from Poozerie landscape province: 4.8–55.8%. An occurrence of this burnsi was maximum in Verkhnedvinskii District (55.8%) and was minimal in three samples (Braslavskii, Gorodokskii and Glubokovskii districts: 4.8–7.7%).

Occurrences of rugosa in Byelorussian populations of the Moor Frog vary from 2.5% (Rossonskii and Kamenetskii districts) to 84.6% (Glubokvskii District). The phenotype is absent in population from Bobruiskii District (Berezina River).

A considerable landscape-typological variability is typical for phenotypes NC and NV. In each province together with populations where these phenotypes are absent or occur at very low frequencies, there are other populations where concentrations of these phenotypes are very high.

The frequency of the phenotypes V+ and V– also vary considerably in all landscape provinces from minimum to maximum values. V+ is absent from the population from Stolbtsovskii District, and in Svislochskii, Kamenetskii and Loevskii districts its concentration is maximal (50.6–51.6%). The frequency of V– in the Byelorussian populations of the Moor Frog varies from 7.6–73.1%. In the large majority of populations from Poozerie and Elevated Byelorussian provinces, it is much higher than in the Republic as a whole. Data from the Table 30 show that the degree of landscape-geographical variability of the phenotypes in the Moor Frog is quite variable.

A comparative analysis indicates significant differences in the range of landscape-typological variability of particular phenotypes in both species of brown frogs. The important difference is that the populations of Common Frog are characterized by a very low frequency of punctata. This phenotype is found only in 5 of 45 samples with occurrences of 1.2–2.1%, while in other parts of the range (e.g., Urals, middle and western Siberia) its frequency is 13.2% (Ishchenko, 1978).

Unlike the Moor Frog, the Common Frog presenting striata are present in a large majority of samples (39 of 45: Table 31; Fig. 38). Its frequency varies from 1.2–22.2%. In contrast to the Moor Frog, a high frequency of the hS (3.2–40.0%) was found in this species. In all landscape provinces the occurrence of hS was quite variable.

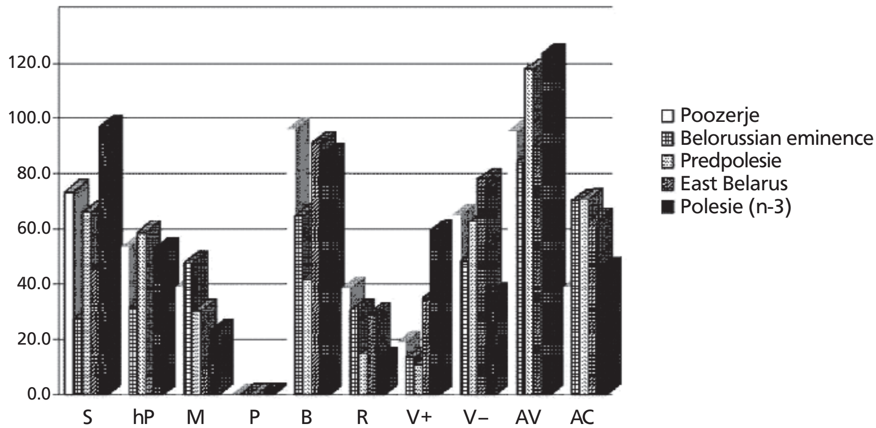


Fig. 38. Degree of phenotypic variability of *Rana temporaria* in different landscapes of Belarus.

A considerable interpopulation variability is typical for maculata throughout all landscape provinces. In the large majority of population series its occurrence reaches more than 30%. Frequency of burnsi is also characterized by considerable variability throughout the territory. In all populations its occurrence is much lower than that of remaining phenotypes (0–16.7%). The concentration of maculata is minimal in the Polesie landscape province (0–6.6%).

One more distinctive feature of the phenotypic structure of the Common Frog populations is a considerable concentration of rugosa (12.0–84.6%). Similarly to other parts of this species range (Ishchenko, 1978), in Belarus high interpopulation variability of this phenotype was found.

Frequency of V+ is very high and comprises a large majority of populations 40.0–71.4%. The occurrence of V– is characterized by a much smaller frequency (0–27.8%). In all landscape provinces considerable interpopulation variability in frequency of the V– was observed. Populations from Poozerie, Elevated Byelorussian and Fore-Polesie provinces are characterized by the highest frequency of V+ (40.0–71.4%). Populations in Dubrovnskii District are notable by having a minimal frequency of V+ (11.1%) among populations of the East-Byelorussian province and the Republic as a whole.

High densities of throat and belly pigmentation and presence of the pigmented variant A is specific to brown frogs (Pikulik, 1985). We estimated the frequency of AC and AV – complete absence of pigmentation on the throat and belly, which is considered atypical for this species. AV is absent in populations from Poozerie, Elevated Byelorussian, East-Byelorussian and Polesie landscape provinces (15.6% of samples studied). In the remaining populations its frequency varies from 2.4–66.9%. Throughout all landscape provinces a considerable interpopulation variability of concentration of this phene was found.

The frequency of the AC is also characterized by a considerable landscape-typological and landscape-geographical variability (0–100%). The main tendencies of landscape-geographical variability of concentration of the phenotypes in the Common Frog differ significantly from those in the Moor Frog. It indicates that the range of coefficients of variation of phenotype values (except for maculata) in different provinces is much narrower in the Common Frog than in the Moor Frog. In addition, the degree of variability of occurrences of the same phenotype in these sympatric species is also different. First of all, this concerns maculata, which occurs in the Common Frog much more commonly than in the Moor Frog.

To evaluate the specificity of phenotypic structure of brown frogs populations in the basins of the large rivers, data from 31 populations of the Moor and 28 samples of the Common frogs (totally 1776 specimens), were analyzed. Significant differences were found for both species in the occurrence of some phenotypes. Differences of phenotypic structure of the Moor Frog populations inhabiting valleys of the largest rivers of Belarus are shown in Fig. 39. These data show that in the floodplain of the Neman individuals with M (36.7%), B (26.9%), and V+ (40.4%) prevail; the frequency of NC (9.1%) is high; and frequencies of R (10.1%), V– (16.9%) and NV (5.0%) are low. The frogs from the Berezina floodplain have low frequencies of M (28.1%) and NC (6.5%) and very high frequencies of B (39.3%), R (28.4%), V+ (30.1%), V– (29.1%) and NV (11.5%). Considerable differences in the frequencies of particular phenotypes in samples from sites along riverbeds in Elevated Byelorussian, Fore-Polesie and Polesie provinces were found. The sample from Osipovichskii District is most specific in phenotypic structure for this river floodplain. NC and NV are

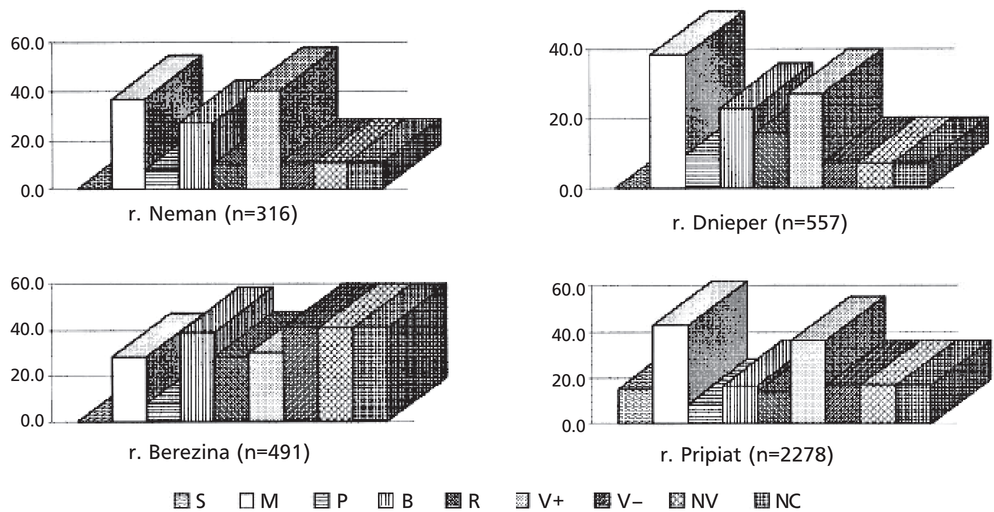


Fig. 39. Mean percentages of phenotypes in *Rana arvalis* (%) in populations on large river plains.

absent, the frequencies of P (2.2%) and R (20.0%) are low, and the frequency of B (53.3%) is highest. In the floodplain of the Dnieper, Moor Frogs dominate with M (38.3%), B (22.9%), V+ (27.2%) and V– (22.0%). Significant differences in the frequencies of the five phenotypes among samples from sites along riverbeds in East-Byelorussian, Fore-Polesie and Polesie provinces were found.

For populations in the Pripyat basin, the presence of the S (15.4%), very low frequencies of B (16.7%) and NV (5.1%), and high frequencies of M (42.5%), V+ (36.1%), and NC (9.0%) are typical. On parts of the floodplain between Pinsk and Mozyr cities, clinal variation in the frequency of S (38.0–0.8%), a relatively low frequency of M (52.3–35.4%), and high frequencies of P (10.0–16.5%), B (8.9–22.6%), NV (3.9–7.4%), and V+ (22.3–31.7%) were observed.

Populations of the Moor Frogs living in the floodplains of the Neman, Berezina, Dnieper and Pripyat rivers are characterized by a specific phenotypic structure. The value of χ^2 calculated separately by mean frequency of each phenotype exceeded the valid level of significance (3.80 and 2.08, respectively) only for NC and P. For other phenotypes, it considerably exceeded tabular values of the parameter for $p = 0.01$ (at $df = 3$ the value χ^2 for phenes M, B, R, V+, V– and NV were 37.56, 189.54, 65.05, 248.0, 28.03, 27.22, respectively).

The greatest differences were found between populations inhabiting the floodplains of the Berezina and Dnieper on the one hand and floodplains of the Neman and Pripyat on the other. For the first two, higher frequencies of V– (29.1–22.0% vs. 16.9–19.2%), NV (11.5–7.0% vs. 5.0–5.1%) and a lower frequency of V+ (30.1–27.2% against 40.4–36.1%) were typical. In addition, the frogs inhabiting the Berezina floodplain are notable for high frequencies of B (39.3% vs. 16.7–26.9%) and R (28.4% vs. 10.1–15.7%) and a minimal frequency of M (28.1% vs. 36.7–42.5%).

A considerable interspecific difference in phenotypic structure of the populations of these two sympatric species was found. In populations of the Common Frog from all river floodplains, the presence of S (1.5–11.1%) and hS (13.9–30.8%) was typical. Frequencies of B (0–7.1%), P (0–2.8%) and V– (2.8–13.6%) were always much lower, and frequencies of R (37.0–72.2%) and V+ (33.3–57.7%) were higher.

Common Frogs from the Zapadnaya Dvina floodplain lacked P, the frequency of S (0.5%) was minimal, frequencies of B (1.7%), V– (4.6%), AC (15.1%), and R (37.0%) were very low, and M was maximal (38.3%). In the Neman floodplain individuals with three phenotypes prevail: M (30.3%), R (41.9%) and V+ (49.1%). In comparison with the Common Frogs inhabiting the Zapadnaya Dvina floodplain, they had higher frequencies of S (5.4%), P (0.3%), and B (4.1%) and lower frequencies of AV (3.5%) and AC (6.9%). Common Frogs from the floodplain of Berezina differed from those from all other rivers of Belarus by a minimal frequency of hS (13.9%) and M (20.7%) and high frequencies of S (11.1%), V+ (57.7%), V– (13.6%), AC (51.5%), P (2.8%), and B (7.1%). Considerable interpopulational variability in the frequency of occurrence of almost all phenotypes from the upper reaches of this river in the Elevated Byelorussian province, from one hand, and

from the middle and lower parts of the channel of the Fore-Polesie province were detected on the other hand.. An increased frequency of R (36.7–63.7%) and a decreased frequency of AV almost by half (22.5–12.0%) was found in the upper reaches to the mouth of the Berezina. Frogs in samples from Osipovichskii District (central part of the Republic) have the most specific phenotypic structure. They differ from all others by the absence of M, P and V– and by a maximal frequency of AV (62.5%) and AC (100%).

Frogs from the floodplain the Dnieper lack P and have the highest frequency of AV (44.3%). The prevalence of M (31.2%), R (46.9%), V+ (45.9%), and AC (31.7%) is also typical.

A unique population of the Common Frog in the zone of range microdisjunctions in the floodplain of the Pripyat near the mouth of the Lan River has the most specific phenotypic structure. P, B and AV are absent, frequencies of hS (30.8%) and R (72.2%) are maximal and the frequencies of M (16.7%), V– (2.8%) and V+ (33.3%) are minimal.

We found that the populations of the Common Frog distributed in the floodplains of the Zapadnaya Dvina, Neman, Berezina, Dnieper and Pripyat rivers differ significantly from others by their phenotypic structure. The value of χ^2 only for hS exceeded the tabular value of this parameter for p = 0.05 ($\chi^2 = 8.19$). For other phenes, df = 4 and value of χ^2 for S, B, R, V+, V–, AV, and AC were 13.72, 26.22, 10.48, 17.44, 27.25, 34.75, 380.09 and 62.17, respectively. Common Frogs from the Berezina and Dnieper floodplains differed significantly ($p<0.01$) from those from the Zapadnaya Dvina, Neman and Pripyat floodplains by high frequencies of AC (51.5–31.7% vs. 6.9–15.1%) and AV (21.4–44.3% vs. 0–10.1%) and higher frequencies of S (11.7–7.6% against 0.5–5.4%), B (7.1–4.9% vs. 0–4.1%) and V– (13.6–7.5% vs. 2.8–4.6%).

M. M. Pikulik (1985) and M. M. Pikulik with coauthors (1983) found ecological specificity of frog populations from the basins of different rivers. Those from the Berezina and Dnieper belong to different landscape provinces. When we compared samples of the Moor and the Common Frogs in one-type ecosystems of different river basins, the highest variation in the population structure occurred along the Berezina River which crosses meridionally the landscape provinces of Elevated Byelorussian, Fore-Polesie and Polesie. Common Frog (100%) dominates in its upper reaches, and Moor Frog (more tolerant to dry climate) begin to dominate in the middle reaches (from 20 to 65.0– 94.5%). In the Polesie (Svetlogorskii District), the Moor Frog dominates completely. A similar tendency is detected along the Dnieper which crosses meridionally East-Byelorussian, Fore-Polesie and Polesie provinces (Pikulik, 1985, 1993). We have also found a specific interrelationship between numbers of brown frogs on the rivers Neman and Pripyat that flow primarily in latitudinal directions within the limits of Elevated Byelorussian and Polesie provinces respectively. Common Frogs dominate on the Neman (88.0–100%), while the Moor Frog prevails on the Pripyat (to 100%).

As a result of ecological analysis and an analysis of morphometric and phenotypic structure of these species, we conclude that landscape features of the territory of Belarus

significantly influence the morphometric structure (Pikulik, 1990; Pikulik and Kosova. 1992; Kosova et al., 1992; Kosova, 1996).

All the data discussed above is evidence that different conditions in the valleys of large rivers of Belarus result in changes of genetic composition of the frog populations that are manifested in heterogeneity of their phenotypic composition. Populations of both species of brown frogs, inhabiting the floodplains of each of the investigated rivers have a specific phenotypic structure. The most significant differences in most phenotypes occur between populations from the floodplains of the Berezina and Dnieper rivers versus all others.

The differences in phenotypic structure in the Moor and the Common frog populations in the floodplains of the largest rivers of Belarus are determined, apparently, by a complex effect of abiotic (e.g., relief character, features of the hydrological regime and climate), biotic (e.g., relationships with other species, competition as larvae) and historical factors. Thus, landscapes, hydrological and climatic features of the river basins determine the conditions of breeding and larval development. The conditions of larval development make a considerable impact in the formation of phenotypic composition of particular generations.

Peculiarities of postmetamorphic growth of amphibians in each population depend on features of the ecosystems, which influence individual growth rate of animals and the density of populations of coexisting species. Smaller dimensions characterize metamorphs that leave the basins with high tadpole density. As compensatory growth in populations is not always apparent, they remain smaller even in older ages as compared with animals that developed in more favorable temperature conditions and lower density. It results in variability of morphometric characters described in many works (Pikulik, 1976a, 1976b, 1977, 1978, 1982; Pyastolova et al., 1982; Ivanova, 1985; Shchupak, 1985). It is very hard to determine the relative role of the particular factors in nature (Pyastolova and Ivanova, 1979).

Variability of morphometrics of the Moor and the Common frogs distributed in Belarus is a result of their long-term adaptation to landscape conditions of these localities and, first of all, change of climate and relief (Kosova, 1996). Apparently, the phenotypic pool of each population of brown frogs in the region is unique. It is a reflection of genetic composition of population and its control by a complex of factors. Ecological structure of populations, ecological specificity of different phenotypes and particular conditions in different ecosystems all play major roles. Abiotic factors determine the breeding success of amphibians, affect ecological structure, and can influence significant genetic composition of a population at different stages of its life cycle (Ishchenko and Shchupak, 1979; Ishchenko, 1987; Ishchenko and Ledentsov, 1993). It is known that urbanization of natural landscapes can cause variability of some proportions and phenotypic structure (Ushakov and Lebedinsky, 1984; Vershinin, 1987; Lebedinsky, 1989; Ushakov and Beloborodova, 1989). The batrachofauna of the central regions and those regions with a low percentage (less than 30%) of forested lands in Belarus is subject to greatest anthropogenic effects. This concerns the majority of districts in Mogilevskaya Province of the East-Byelorussian

landscape province as it is the most changed by the agriculture activities, and large areas of intensive modifications occur in the Byelorussian Polesie (Pikulik, 1985). The status of the batrachofauna and phenotypic pools in natural populations in these regions also are determined by conditions of breeding. A deficiency of small wetlands and their fast drying occurs more commonly after anthropogenic pressures are applied. All of these can result in deterioration of growth and development conditions, increase mortality, the duration of metamorphosis, and the number of metamorphs, and change the ratio of the next generations of the Moor and the Common Frog. These alterations can change the morphometric and phenotypic structure of populations (Pikulik, 1976, 1977, 1978, 1985, 1993).

At the same time, the landscape-geographical variability of morphometric and phenotypic structure of the Moor and the Common frogs can be determined by historical causes, such as differences in species habitats earlier in the Holocene. The governing influence on the process of creation of modern landscapes and fauna of Belarus, as indicated above, was influenced by the last two glaciations. Their boundaries extended into central and Poozerie landscape provinces (Landscapes of Byelorussia, 1989). At the regression of these glaciers, the distribution and ratio of the Moor and the Common frogs on the territories of particular landscape provinces were determined by the character of relief, drainage network, composition and structure of floristic complexes, ecological specificity (greater dependence of the Common Frog on humidity and hibernation in flowing water) and evolutionary potential of these species. As we know from data on the herpetofauna of the Pleistocene and Holocene deposits on the territory of Belarus and adjacent regions (Borkin, 1984), the Moor Frog is known from deposits of the Early Holocene of western Ukraine and the Late and Middle Pleistocene of Germany, France, Poland and the Volga region. According to paleontological records, this species was distributed in Europe from the Volga to France (i.e., to the west of the present range, already in the Middle Pleistocene). During the slow regression of the glaciers, there was a gradual migration of amphibians into adjacent territories and penetration into the territory of Belarus. According to Kalinovsky, Polesie Lowland and, consequently, the populations of Moor Frog inhabiting it are more ancient compared with populations of this species from other landscape provinces of Belarus. Common Frog, which by virtue of their ecological specificity could not inhabit the Pripyat floodplain because of considerable spring overflows, could penetrate into the territory of Belarus from the southwest and southeast by the channels of Neman and Dnieper rivers.

Chapter 6.

REPRODUCTION AND DEVELOPMENT

Reproduction is a key problem in amphibian ecology and conservation. In spite of high breeding rate and fast growth, breeding potential can vary considerably because of the regulating effect of natural factors (e.g., weather, climatic conditions during the breeding season, food resources, and natural enemies). As a rule, less than 1–5% of embryos survive to complete metamorphosis in most temperate anurans of Europe. Larvae of Anura, that eat mainly algae, play an important role in the processes of accumulation and transformation of organic matter in aquatic ecosystems and also in its transmission to the terrestrial ecosystems at metamorphosis. Analysis of the dynamics of growth and development in amphibian larvae has a high scientific interest. Large number of amphibians is concentrated in various species combinations in the breeding season in water bodies. Their analysis allows us to clarify mechanisms and fundamental principles of structural and functional organization of natural communities.

6.1. Phenology of Reproduction

The aquatic phase of the life cycle of amphibians of temperate zones of Europe include breeding, embryonic and larval development, and in some species also hibernation. Often this is a key stage influencing success of functioning and viability of populations. The process of reproduction in amphibians is connected not only with many parameters of their natural populations (e.g., reproduction, demographic structure, and number), but also the ecological structure of communities in riparian ecosystems where they often play the main trophic role.

Our studies have shown that breeding phenology, namely time and duration of the spawning season, embryogenesis, larval development and metamorphosis, is an important factor of ecological differentiation of amphibians.

As comparative analyses have shown, several groups of species in the batrachofauna of Belarus may be distinguished by calendar terms of spawning and its duration and temperature conditions (Table 32).

1. Early-spring group with short breeding season. This group includes the Common and Moor frogs and the Common Toad. Mean dates of spawning in central Belarus based on data from 1985–2003 falls between 5–20 April. In abnormal years it can shift by 5–7 and more days earlier or later. In the southern part of the Republic breeding of these

Table 32. Time and duration of the spawning season in different species of amphibians in the central part of Belarus.

Species	**Time**																							
	April						**May**						**June**						**July**					
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
R. temporaria	+	+	+	+																				
B. bufo		+	+	+																				
R. arvalis		+	+	+																				
P. fuscus			+	+	+	+	+	+																
R. esculenta						+	+	+	+	+	+	+	+	+										
T. vulgaris				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+						
B. viridis							+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		
B. bombina								+	+	+	+	+	+	+	+	+	+	+	+					
H. arborea								+	+	+	+	+	+	+	+	+	+	+	+	+				
T. cristatus							+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
B. calamita									+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Note: the month is divided on six 5-days periods: 1 – from 1st to 5th day of month, 2 – from 6th to 10th, 3 – from 11th to 15th, 4 – from 16th to 20th, 5 – from 21 th to 25th, 6 – from 26th to 30th (31 th).

species occurs about 5–8 days earlier and in the northern they breed 5–10 days later than in the center. Such differences in the chronology of spawning in amphibians in different geographical regions of Belarus are typical for all other species in the country. The above mentioned species breed in water bodies with stagnant or slowly flowing water with temperatures 9–15°C (sometimes to 6°C). Fluctuations of weather and climatic conditions in spring often lead to sharp fluctuations of water level and the temperature of the water bodies. This produces a considerable influence on the time and success of reproduction.

2. Late spring group with short breeding season. This group includes the Common Spadefoot and the complex of green frogs represented by three species (Marsh, Pool and Edible frogs). Breeding of the Common Spadefoot starts on 15–20 April and is completed in the first week of May (occasionally, for example in 2003, in the second half of May). The breeding season of green frogs extends from the end of April to the end of May or beginning of June, although the mating calls of males can be heard to the end of summer. These species breed in variable, rather deep (0.6–1.2 m) water bodies with still or flowing water with temperatures from 12– 22°C.

3. Spring–early summer group with long breeding season. Smooth Newt belongs to this group. Its breeding season extends from the middle of April to the end of June. In all probability, late breeding is a result of repeated spawning of some individuals. It is also possible that it is connected with breeding of the earliest generation of previous years that attained sexual maturity at the beginning of summer (according to our data, sexual maturity of the Smooth Newt is in the 3rd year of life). Water temperatures in breeding habitats in this period varies from 5–22°C.

4. Summer group with a long breeding season. This group is represented by the most species and consists of the most thermophilous forms: the Green and the Natterjack toads, Fire-Bellied Toad, Tree Frog and Crested Newt. They breed in well-warmed basins, as a rule, with still water at temperatures of 15–25°C. Their reproductive seasons cover the period from the beginning or middle of May to the end of June and even the beginning of July, although the peak breeding activity falls during the middle – end of May. Late egg deposition is explained by biological features of these species and specificity of breeding habitats which often dry up in summer and thus influences migrations and repeated breeding. Temporal and spatial structure of populations of these amphibians while breeding season depends on the level of precipitation and water supply in wetlands to a greater degree than in other groups.

This classification really has only an "operating" character, as breeding periods in many species overlap considerably. However, it reflects ecological differentiation of amphibians based on the time and duration of the breeding season. There is an important regularity, which partly explains dynamics of their populations. Early breeding species (*R. temporaria, R. arvalis, B. bufo*) have the widest distributions, highest numbers and population densities, and often prevail in the structure of amphibian complexes. On the other hand, the most thermophilous group, *B. calamita, H. arborea, B. bombina,* and *T. cristatus* breed the latest and have prolonged reproductive periods, and a restricted distribution in Belarus and have considerably smaller populations. Evidently, each taxon (genera *Rana, Bufo, Triturus*) may include very similar and quite different species based on reproductive processes and tactics.

An analysis of the composition of breeding associations of amphibians, based on data from 176 water bodies in Belarus has shown that up to 10 species can alternately use the same water body as breeding habitat during one season (Fig. 40). Assemblages consisting of 3–5 species are the most frequent. Groups with the highest and lowest taxonomic diversity

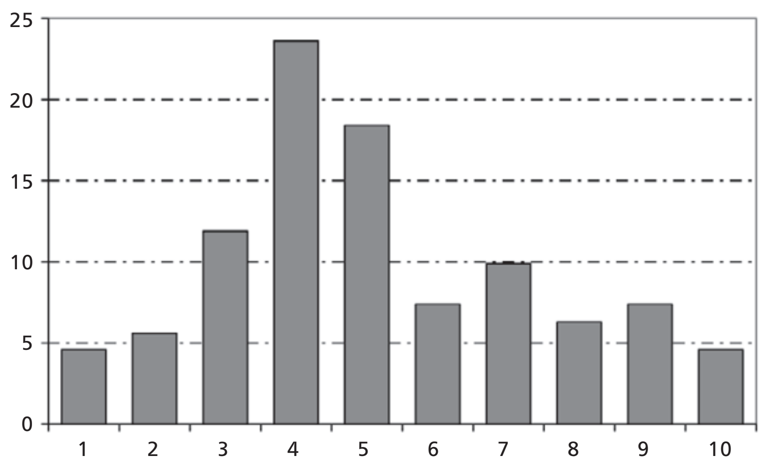


Fig. 40. Structure of breeding assemblages of amphibians based on the number of jointly breeding species.

are rather rare. Stable (not drying up in the dry season and existing for many years), shallow (to 1 m), well-warmed water bodies with still or weakly flowing water where the greatest number of species reproduces had the greatest ecological capacity among different aquatic habitats. Among communally breeding species, differences in ecological niches based on the activity rhythms exist in most cases.

Against a background of a variety of combinations of communally breeding species, there are some characteristic combinations. For example, about 30% of the breeding associations in Polesie are composed by a complex which includes Moor and green frogs, Fire-Bellied Toad and Tree Frog. In about 10% of the spawning grounds Smooth and Crested newts, as well as Green Toad coexist. The rarest component of these breeding assemblages is the Natterjack Toad which prefers to breed in specific wetlands not rich in other species. The results of comparative analysis of ecological parameters of breeding wetlands (e.g., depth, temperature, character of water supply, presence of vegetation, structure of littoral zone etc.) supports the assumption that breeding communities of amphibians in Polesie are formed mainly as a result of superposition of similar ranges of tolerance of separate species.

Differences in phenology of breeding of amphibians, based on asynchronous reproductive cycles, are an important dynamic aspect and one of the mechanisms of the formation of sustainable structure of their assemblages and natural communities as a whole.

6.2. Spawning

The Common Frog is the most cold-resistant and early-spawning species in Belarus. Amplexus in this species is observed 2–6 days after leaving the hibernacula and in 1–9 days (depending on the temperature) spawning occurs. Amplexus was noted not only in breeding habitats but also in hibernacula with flowing water and on land enroute to the spawning place. Deviations from normal reproductive behavior often occur, which are displayed in clasping of conspecific males and green frogs males, Common Toads, different objects and dead bodies of other amphibians.

Males prevail in breeding aggregations of the Common Frogs. They compose 80% of individuals caught from the hibernacula and 70.2–95.5% of frogs caught on the breeding grounds. Probably the shortage of females excites males of the Common Frog to clasp individuals of other species. In breeding aggregations of the Marsh Frog, which form during the first days of May, males also prevail (up to 95%). Observations of breeding aggregations of amphibians have shown that in some species, for example the Common Toad, male-male competition for female is notable.

Spawning of Common Frogs in Belarus begins on the day that water temperatures in the breeding grounds is not lower than 9–10°C, even if mated pairs are already present. Breeding grounds are more or less uniform. They are covered by decayed herbaceous

vegetation and well-warmed by the sun in the daytime. Water temperatures average 4–5°C higher than in adjacent deeper areas. Although some water bodies contain ice during the breeding times, the egg deposition occurs in ice-free areas. Spatial distributions of breeding sites in the Common Frog vary insignificantly by years. For example, in the Berezinsky Biosphere Nature Reserve and near Minsk City, the positions of breeding sites were consistent during 10–14 years. Breeding Common Frogs prefer overgrown littoral areas with depths of 10–20 cm in open, large (not less than 200 m^2) and deep (to 50–120 cm) water bodies. In preferred habitats 50–70% of all spawn is deposited. If suitable water bodies are deficient, Common Frog also deposits spawn in back-waters of open and wooded streams and small rivers. Body lengths of males participating in breeding are 51.0–79.8, females 51.0–67.2 mm. According to the minimum sizes of individuals in amplexus, Common Frogs attain sexual maturity at body lengths more than 51 mm.

The intensity and duration of spawning in the Common Frog in natural conditions depends on water temperatures in water bodies used for breeding (Fig. 41).

Rises in water temperature above 12–13°C causes breeding in all mature individuals, and it is completed quickly. With unstable weather, especially in the first part of the breeding season, spawning can be delayed considerably. The duration of spawning in Common Frogs in different seasons and in different localities can vary from 4–6 to 26 days.

A large part of spawn deposition, as a rule, in a local pool occurs in aggregations of 2–3 or sometimes 10 m^2. Spawn deposited later is situated on top of earlier spawn. One aggregation may include 40–90 clutches (maximum 400). The density of Com-

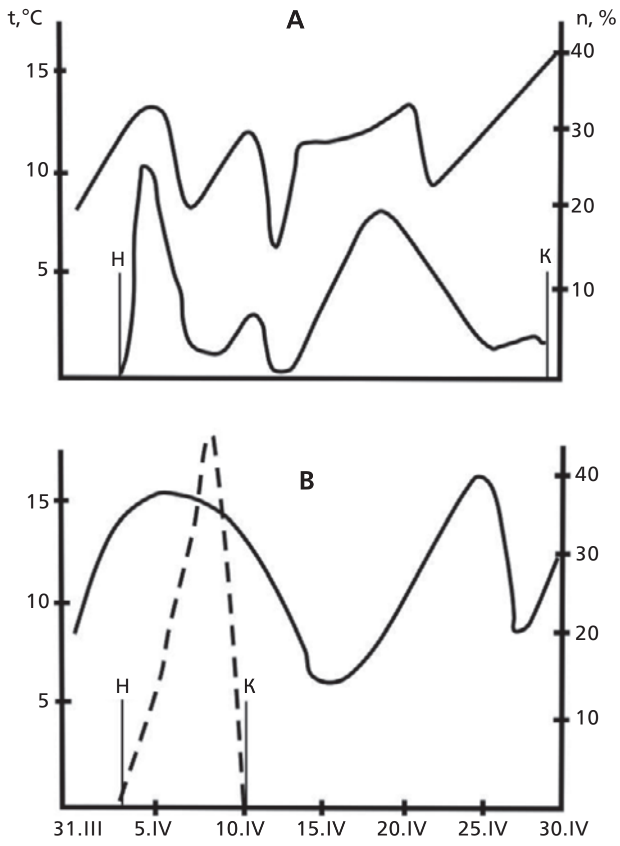


Fig. 41. Dependence of intensity and duration of spawning in *Rana temporaria* on water temperatures in April in two consecutive years (A, B). Solid line = temperature of water (t,°C) during the daytime (12.00 h), dotted line = number of clutches (n, %). H and K = beginning and end of spawning.

mon Frog clutches, probably, is determined by the early breeding which takes place at a relatively low mean day temperatures and light night frosts. Grouped clutches hold heat well, and temperatures inside the group is higher than the temperature of the surroundings by 2–3°C.

Our observations indicate that the presence of overgrown sites, where the temperature of water and oxygen concentration is higher, is a key factor in the choice of places for mass spawning of the Common Frog. Later, because of warming, the same places are most favorable for embryonic development and the first stages of larval development. Presence of appropriate breeding wetlands and choice of the most suitable places for spawning influences the breeding possibilities and reproduction in populations of the Common Frog. Observations in different years and regions have shown that not less than 40–50% of spawn of this species dies from drying before the completion of embryonic development.

In typical years, the Moor Frog starts breeding a little later then the Common Frog. The period of spawning in the central part of Belarus usually occurs from the beginning to the end of April. In Polesie, where the Moor Frog is a dominant species, its spawning usually begins in the last week of March to the beginning of April. Chronographic and geographic variability in the phenology of Moor Frog spawning are similar to those of the Common Frog and depends mainly on temperature. The duration of spawning can fluctuate from 2–25 days. The places of spawning in both species of brown frogs are more or less similar. Usually it is in a littoral area that is overgrown by grass, but occasionally Moor Frogs spawn among plants deeper (to 40 cm) than in the Common Frog. From 20–25 aggregations of spawn/ha (10–100 clutches in each) are deposited in a wetland. Clutch density in the Moor Frog is less than that in the Common Frog. As in the latter species, up to 50% or more of clutches die of desiccation. Dead eggs are white and contrast with the background of developing spawn. A considerable number of clutches die that are laid in peat bogs with high acidity (pH<4.0).

Marsh Frogs in central Belarus start activity in the beginning to middle of April, but mating calls of males and amplexus start in the first week of May when mean daily water temperatures reach 14–16°C. The beginning and intensity of spawning are directly related to temperature. It determines geographical variability in phenology of this species, which in southern and southwest regions of the Republic begins 10–15 days earlier than in the north. The period of spawning takes usually not less than 30–35 days. From year to year places of the Marsh Frog spawning are almost the same. The majority of individuals prefer to breed in large, deep (to 1.2 m and more) ponds overgrown by aquatic vegetation. Green frogs form large aggregations in the main breeding sites. In a series of ponds we counted 30–40 specimens/m^2. Body lengths of breeding individuals of the Marsh Frog near Minsk City vary from 51.3–130.5 mm, but a large majority is 65–80 mm. The density of spawn does not exceed 3–5 clumps/m^2 of water surface. Breeding aggregations, in contrast to brown frogs, can often change places in the pool depending on wind direction and other conditions.

6.3. Embryonic and Larval Development

The duration of larval development in the Common Frog in different ponds and conditions depends mainly on water temperature and can vary from 5–25 days (Fig. 42). Egg clumps can survive spring frosts for 6 days when the breeding ponds during night and morning are covered by ice. The development of late clutches is faster than earlier ones (sometime by 7–9 days) because of warmer temperatures (1–2°C).

Hatching of the Common Frog from large aggregations of clutches in each pond take less time than from single clutches. The hatching of larvae from a mass of egg clutches begins 3–5 days earlier than those from separate ones.

The egg clutches of the Moor Frog in the same pond conditions develop slower. Embryonic development of the Moor Frog encounter frosts in the second week of April by 20–21 days, while the Common Frog develops faster (15–16 days).

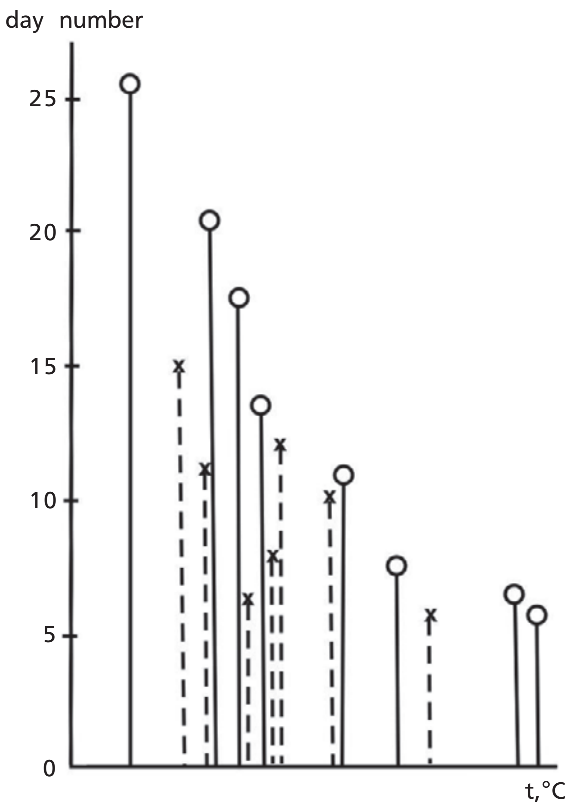


Fig. 42. Dependence of the duration of embryonic development in *Rana temporaria* based on water temperature.
Y-axis = time to hatching, X-axis = mid-day water temperature (t,°C), solid line = data of investigations near Minsk City.

Green frog embryonic development takes 5–9 days at temperatures of about 17–23°C. The egg clusters of green frogs develop in warmer (5–10°C) water, but they have similar embryonic development times as the brown frogs.

Thus, the mass species of amphibian in Belarus differ by the rate of embryonic development and depend on water temperature.

The first larvae of the Common Frog hatch and swim between egg clutches. Water temperatures between egg clutches are higher by 3–4°C than in the surroundings (12–13°C). As a rule, the larvae stay several weeks in dense aggregations near the breeding sites. For 20–30 days, when a large number of larvae reach stage 26 (according to Terentjev, 1950), they gradually disperse.

Usually, from the period of leaving the egg until metamorphosis takes 50–65 days. The duration of embryogenesis depends, first of all, on the

temperature. As shown on Fig. 43, in warm year the development is 10–15 times faster. The rate of larval development varies by years and ponds.

The development of larval hatched from late clutches is much shorter because early stages develop at better temperatures and feeding conditions. If water temperatures exceed 30–33°C in July, the larvae die. Probably, that temperature is limiting for the Common Frog larvae.

Larvae of the Common Frog are killed by numerous aquatic invertebrates, especially water beetles and their larvae. In some ponds about 95% of the larvae (length more then 7–10 mm) are killed by larvae of aquatic beetles and dragonflies. The larvae of amphibians are common victims of vertebrates. Cannibalism rarely occurs in the complex of green frogs and the Green Toad.

Characters of larval development in the Marsh Frog differ notably from the development of brown frogs. As spawning of this species takes place in many sites of a pond, tadpoles stay in all areas and hang onto aquatic vegetation. Later, at stage 26, they form aggregations in the littoral zone. Because of a very prolonged (25–35 days) spawning in the Marsh Frog, the age composition of larvae in a water body is very unequal. From the moment of completion of the embryonic development by the latest embryos, 30–40% of tadpoles already reach the stage 26 and have body lengths of 7.5–11.5 mm.

Although the development of larvae in the Marsh Frog occurs at higher water temperature than that of the Common Frog, its period of larval development is longer. The period from the appearance of first hatchlings to the completion of metamorphosis takes 75–100 days. The rate of larval development depends significantly on weather conditions, and its duration can differ from year to year by 5–25 days. However, the growth rate in the Marsh Frog larvae is higher than in the Common Frog. At stage 26, body lengths of tadpoles attain 14–16 mm and before metamorphosis they grow to 24.5–28.5 mm. Thus, larvae of the Marsh Frog have developmental period about 1.5 times longer than that in the Common frog and about twice that at the beginning of metamorphosis.

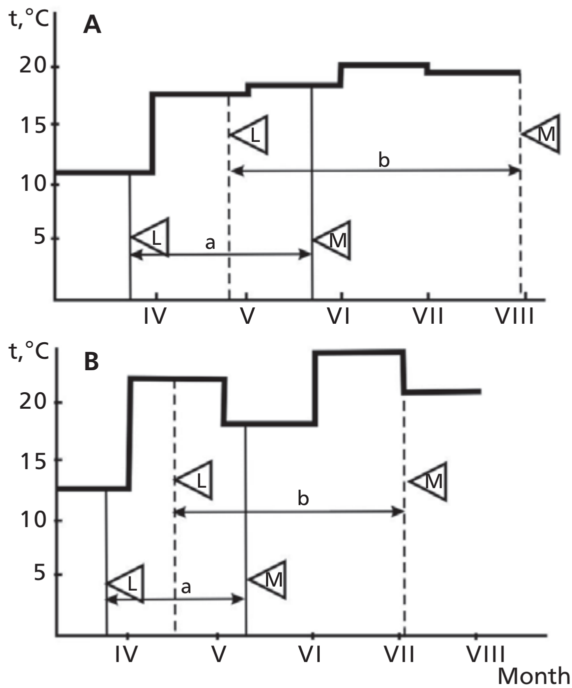


Fig. 43. Larval development periods in (a) *Rana temporaria* and (b) *R. ridibunda* based on temperature conditions at different seasons over two years (A, B).
Solid line = mean water temperature (t, °C), L = hatching, B = beginning of metamorphs leaving the water.

Water temperatures above 30–35°C is lethal. Observed cases of mass mortality of larvae from heat in shallow wetlands with black peat bottom serves as evidence. Metamorphosis in Marsh Frog occurs from the beginning of August until the end of September (i.e., prolonged and variable by year). In some cases not all larvae complete metamorphosis because water temperatures falls to 12–13°C, development stops, and all larvae die.

When syntopic, the tadpoles of the Moor Frog hatch, at least, 3–5 days later than those in the Common Frog. In this connection, larvae of the Moor Frog in a water body are always younger and smaller. Common densities of larvae of these species in the same pools are 2–3 times higher than in basins with solitary breeding.

At joint breeding sites of the Common and the Marsh Frogs, we did not find any negative effects of larvae of one species on the development of the other, although it is known that spawning of the latter species sometimes occurs in unusually shallow wetlands where the Common Frog breeds earlier.

In the Common Frog, 7–10 days after hatching large number of larvae in all water bodies in different seasons are in stages 21–22 with mean body lengths from 3.29±0.04 to 3.73±0.04 mm. The variability of body lengths by wetlands is insignificant and the coefficient of variation varied from 7.6±1.7–9.2±0.83%. Growth and development of tadpoles in each water body occurs nonuniformly. Not all larvae simultaneously reach the next stages of development; and differences in body lengths are clear. The strongest differentiation of larval groups is observed before the appearance of metamorphs. However, differences in this time are insignificant. We suppose that the main growth of larvae in the Common Frog occurs in stages 23–26. In basins with a higher density of tadpoles their growth and development are slightly retarded. Larvae progress through the corresponding stages of development with smaller body sizes, the transition to later stages of development occurs based on their interrelation at different stages, less intensively. In years with higher water temperatures, larvae not only undergo metamorphosis more quickly but also complete it

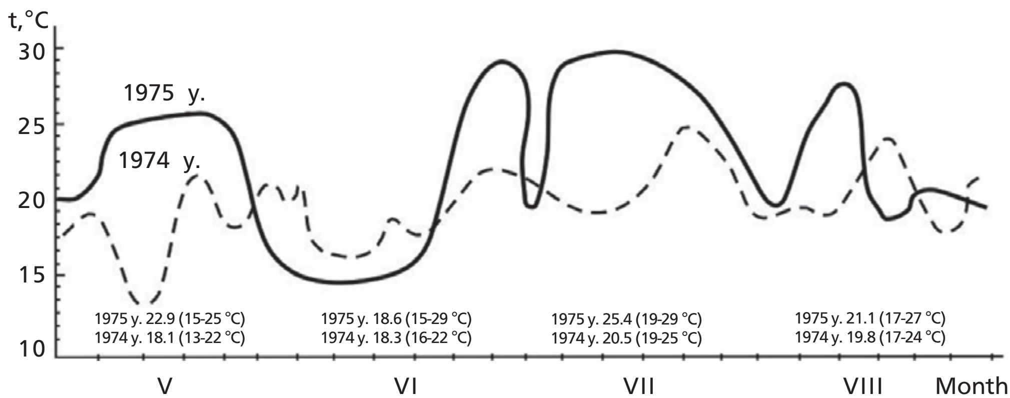


Fig. 44. Dynamics of water temperature (t, °C) in the breeding pools of *Rana temporaria* in different seasons.

earlier. This has an important ecological value and influences population size (from the point of view of a survival rate of metamorphs at hibernation) because earlier movements to land provides a greater period for growth and accumulation of energy storage before hibernation. This supposition may be applied to accelerated development of eggs and larvae from late clutches.

A data analysis indicates that water temperature has a significant influence on the growth and development of larvae in the Common Frog (Fig. 44). In years with higher water temperature larvae not only pass through metamorphosis more quickly but also complete it earlier.

The non-uniformity of larval development clearly shows that the period of moving onto land is considerably prolonged in comparison with the period of larval hatching. Thus, with a period of hatching of 4–6 days, moving onto land takes 24–39 days. Our experimental studies (Pikulik, 1977) show that non-uniformity of growth and development of larvae, determined by hereditary factors, can be sharply strengthened by the effect of interpopulational regulatory mechanisms. The ecological value of non-uniformity of completion of metamorphosis seems to involve the prevention of simultaneous appearance of young frogs on land, as this can result in their mass overcrowding and loss because of resource limitations.

The major importance of breeding and developmental conditions for amphibians should be taken into account during the organization of complex nature protection measures.

Chapter 7.
ANTHROPOGENIC INFLUENCES AND CONSERVATION

Until very recent times, amphibians attracted much less attention regarding the problems of conservation compared with other groups of vertebrates. The main cause of this involves, apparently, the absence of their high practical significance. In countries of central and eastern Europe amphibians are used very little. Some anurans are used as a source of medicinal drugs (e.g., cardiotonic agents, immunostimulants) in traditional medicine, as a subject to laboratory researches, as food and some other purposes.

The very important role of this group of animals, which they play in the structure of natural communities, function and bioenergetics of the ecosystems because of their large numbers and productivity, is underestimated. High sensitivity to influences of various natural and anthropogenic factors, small body size, dense populations and mass occurrence in terrestrial and semiaquatic ecosystems allow us to estimate that amphibians are one of the most convenient models for ecological monitoring and biological indications of the conditions of natural ecosystems.

The necessity to develop a complex of special measures concerning amphibian conservation is determined by many global and regional causes. The conservation of biological diversity, including particular taxonomic groups of animals irrespectively of their practical value, is one of the most important problems in modern human society. High intensity and diversity of many forms of anthropogenic effects influence the modern state of the fauna, and natural communities determine special character and priority of solutions to this problem for Eastern Europe and Belarus.

7.1. Main Anthropogenic Factors

The modern state of the amphibian fauna of Belarus is connected with the influence of many natural and anthropogenic factors. As described above, there is a significant landscape-dependent variation in the dynamics of populations in this region.

In the broad spectrum of anthropogenic factors, which directly or indirectly influence the amphibians of Belarus, drainage of swamped lands, urbanization, destruction of forests, and chemical and radioactive contamination of habitat are of primary importance. Because of high geographical, landscape and anthropogenic differentiation of the territory, there are regional and local events that influence populations in this group.

At the end of the 1980s, Belarus, being a part of the USSR, was characterized by intensive development of industry, agriculture, fast urban growth, expansion of a dense network of highways, increase of traffic, increases of minerals production and nature resources development, and fast development of ecological tourism and other forms of recreation (Pikulik, 1985).

At present, the common trend of anthropogenic transformation of natural landscapes and fauna is still connected with a general reduction of the area of natural habitats. In such conditions, animals adapt to modified living conditions. The economic recession which embraced the Republic at the end of the 20th century has reflected also on the state of its fauna and amphibians in particular. It was manifested in the form of decreasing influence of some of the most significant factors (e.g., drainage engineering and chemical pollution of environment). However, the scales of their consequences and the modern situation still remain considerable. In the same period some other, partly new, anthropogenic factors producing deteriorating effect on amphibian populations have appeared or sharply increased. Of special significance, in particular, was the radioactive contamination in part of the territory after the Chernobyl catastrophe, fast growth of car traffic, high rates of building (e.g., urban houses, dachas, and cottages) and some others.

One of the most important regional factors of anthropogenic transformation during the entire 20th century was wide-scale drainage of wetlands. In the1960s–1980s, as a result of intensive activities on land reclamation, especially actively conducted in vastly modified region of Polesie, natural structure of faunistic complexes and the ecology of the majority of amphibian species have changed considerably.

Specific amphibian complexes, which in species composition and structure are somewhat similar to some communities of open meadow ecosystems, have formed on drained lands. In regions of the most intensive drainage works, an irreversible restructuring of amphibian complexes, spatial reallocations, and reduction in number and modification of populations structure of the majority of amphibian species take place (Pikulik et al., 1987, 1988; Khandogii, 1995, 2000, 2001). These data indicate, on one hand, the negative effect of this factor on the state of faunistic complexes and species populations, and on another, the high ability of many species to develop adaptations for new ecological conditions.

Nevertheless, the response of amphibians to the effect of land reclamation is not always unambiguously negative. In some regions suitable artificial ecosystems were formed near drained untouched areas of natural ecosystems, and the density of populations not only did not reduce but have also increased in comparison with initial swamped grounds. The density of populations in many anurans (e.g., *R. arvalis, P. fuscus, B. bufo, B. viridis*) on agricultural fields established on drained grounds quite often reaches 150–1130 specimens/ha.

Open areas of meadow and agricultural fields of reclaimed lands, that have an extensive network of drainage channels, became optimal feeding grounds for amphibians. Because of the high numbers of invertebrates, wide spectrum of potential prey and poorly developed

feeding selectivity, amphibians play an important role in structural and functional organization of the transformed ecosystems and regulation of prey invertebrates populations, including numerous pests of agriculture. The slow flowing channels of drainage systems are favorable habitats for breeding of the majority of species. Building of flood dams, modified systems and polders with a regulated hydrological regime in the middle reaches of the widely flooded Pripyat River promoted dispersal and increasing number of the Common Frog, a formerly rare species in that area.

At present, the scales of modifications in Belarus are sharply reduced because of the complex economic conditions and detected negative consequences caused by total drainage. This process was stopped, but its outcomes, certainly, will be manifested for a long time.

The effect of urbanization, the other important anthropogenic factor, leads to significant change or even complete degradation of amphibian habitats, influences process of reproduction in amphibian populations on the territories of continuous industrial or urban building, and results in fast decline of species diversity and population size. Ecological and faunistic studies conducted in recent years in different settlements, including such large cities as Minsk, Grodno and Brest, have shown that the most adaptable to transformed habitats are Green Toad, brown and green frogs, the Tree Frog and the Fire-Bellied Toad in southern and southwestern parts of the Republic (Yanchurevich, 2001; Gumennyi, 2001; our data).

Flattened floodplains of rivers and channels, riparian areas of ponds, water storage basins and lakes, urban parks and recreational forests with presence of vegetative cover and wetlands suitable for breeding remain the parts of urbanized landscapes most suitable for amphibians. The spadefoot, Crested Newt and Natterjack Toad are the most sensitive to urbanization. They are extremely rare in the conditions of urban landscapes.

The continuous cutting of forests caused by the necessity of intensification of agriculture, urbanization, forest amelioration, building or other forms of human economic activities also lead to the reduction of the area of natural habitats for the majority of amphibians, rearrangement of spatial structure of populations and their fragmentation. During anthropogenic transformation of natural landscapes and subsequent restoration, successions of vegetative cover and structure of faunistic complexes of amphibians change considerably. Dramatic alterations of vegetative cover and the hydrological regime and microclimate of habitats caused by the growth of cities and other settlements produce the major effect on amphibians.

Special ecological analysis revealed that during the first 3–7 years of vast clear-cutting only 1–3 species of amphibians are recorded. Among them, as a rule, are the most eurytopic representatives of the fauna, the Moor and the Common frogs, Common Toad and some other. Species diversity in overgrown clearings is formed at the expense of animals surviving after cutting and stubbing of trees, as well as by emigrants from adjacent ecosystems. The intensity of the process of invasion into new ecosystems is correlated with the square of tree cutting and presence and diversity of water bodies.

A significant negative result for amphibian populations has been the pollution of basins by waste water with high concentrations of mineral fertilizers, insecticides and pesticides coming from adjacent agricultural areas. In particular, we repeatedly noted that extremely low numbers of amphibians are found near fields of cereals where insecticides are used regularly.

Although it is not possible to provide a complex quantitative estimation of the effects of many anthropogenic factors on amphibian populations, understanding of the influence of traffic movement is possible.

Numerous records on highways with different cover (e.g., ground, concrete, and asphalt), different values (e.g., transeuropean, republican, regional, and district) and different intensity of the traffic (1–2 vehicles/day versus 1200–2000/h) indicated that a large number of amphibians are killed each year. An example is the highway Brest – Moscow with very intensive vehicle traffic and amphibians movements. In the season of mass spring migrations of amphibians, on sections measuring from 50–450 m, during 10–14 days on each 10 m^2 from 2–10 individuals were killed by cars, which calculates to 430–2500 individuals during one season (Figs. 45 and 46).

The most active breeding migrations are typical for the Common Toad, Moor and Common frogs, and Spadefoot Toad. The most intensive movements of amphibians occur at night near low, swampy and wooded landscapes. The proportions of different species killed on motorways in central Belarus, according to generalized data collected in 2000–2002, are given in the Table 33. The influence of intensive vehicle traffic and the increase of motorways network makes it possible to consider not only the factor influencing breeding migrations of amphibians but also an important aspect of infrapopulational differentiation, which in some extreme cases can result in isolation of separate groups.

As a result of the Chernobyl catastrophe, which occurred on 26 April 1986, a considerable part of the territory of Belarus and especially its southeastern parts were contaminated by

Fig. 45. Adult *Bufo bufo* killed by a car on a road.

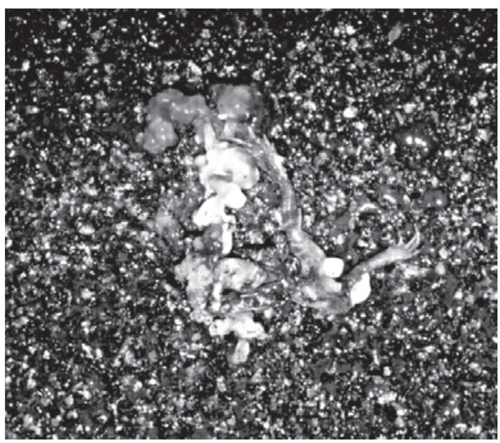


Fig. 46. Adult *Rana temporaria* killed by car on highway.

Table 33. Species composition and proportion of different amphibian species killed by cars on motorways of Belarus.

Species	Dead amphibians found	
	Number of specimens	%
B. bufo	165	25.08
R. arvalis	132	20.06
R. temporaria	119	18.09
P. fuscus	67	10.18
B. viridis	45	6.84
T. vulgaris	39	5.93
R. esculenta complex	29	4.41
H. arborea	10	1.52
B. bombina	7	1.06
B. calamita	6	0.9
T. cristatus	5	0.76

the products of radioactive decay. Belarus was the most affected region of Europe, because about 70% of the blowout fell on its territory (International Chernobyl Project, 1991).

The long-term radioecological monitoring conducted since 1986 shows that the main tendencies of the spatial and temporal dynamics of the radioactive contamination of amphibians and the dynamics of some ecological processes related to the catastrophe (Drobenkov et al., 2001). According to the results, the effect of radioactive contamination of the territory on the fauna and amphibians in particular is manifested in two main directions.

1. Direct effect of ionizing radiation on organs, tissues and biological functions of animals (contamination by radionuclides of technogenic origin); and

2. Ecological effects connected with the reduction of anthropogenic load on ecosystems, complete resettlement of local populations and succession processes which are proceeding intensively in the region of Chernobyl Station (Fauna in the Region of Chernobyl, 1995).

Analysis of materials collected in the region of radioactive contamination has shown that the maximum levels of activity for amphibians in the whole period of observations were found in the liver and muscles of the Moor Frog and the Common Frog: 5.85–85.1 kBq/kg. The highest parameters of beta-emitters were recorded in the Fire-Bellied Toad: 1.08–539.23 kBq/kg. Significant interspecific differences in the degree of accumulation of radionuclides were not found because of high individual variability and extreme patchiness in density and composition of the radioactive products on the contaminated territory.

From the estimation of temporal dynamics of accumulation of radionuclides in tissues and organs of amphibians in the region of Chernobyl, we conclude that the intensity of radioactive contamination of amphibians from 1986–1997 decreased by several times (Fig. 47). Immediately after the catastrophe, a composition of emissions of 21 radionuclides was recorded. Now, about 85% of the radionuclides with a short half-life have decayed

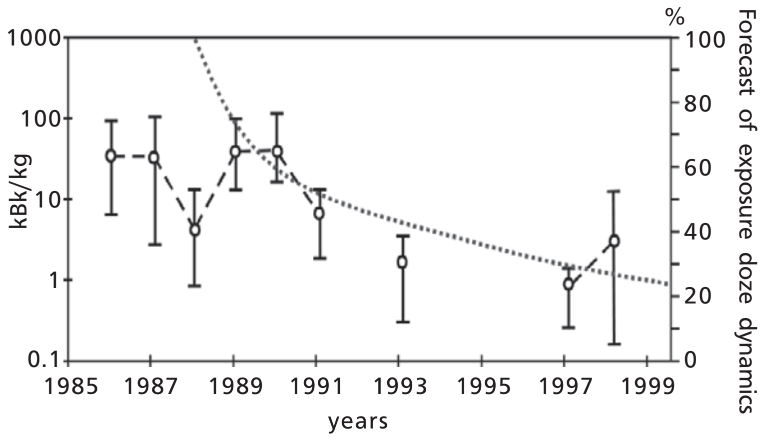


Fig. 47. Dynamics of the accumulation of g-emitters by amphibians and its forecast by Bulavik and Perevolotsky (1998).

(Yakushev et al., 1998). The main dose-generating factors after short-lived elements decay are the isotopes ^{137}Cs, ^{134}Cs and ^{90}Sr.

The results of ecological analysis of amphibians have shown that a clear dependence between the level of a radiation background and radioactivity of samples from animals taken from the contaminated regions occurs as on moves away from the Chernobyl Nuclear Power Station. The materials did not reveal a reliable connection between the radionuclide content with ecologically different groups of amphibians. In particular, there was no significant differentiation relative to the degree of accumulation of radioactive elements in the Spadefoot Toad, which inhabits the driest habitats, and such amphibians as the Green Frogs and the Fire-Bellied Toad, which live in humid riparian areas and in water.

The mechanisms and consequences of the influence of radionuclides on organisms and the biological functions of amphibians are poorly studied. Cytogenetic researches of recent years revealed some common regularities in the effects of ionizing radiation on amphibians in the region of the Chernobyl catastrophe (Aphonin et al., 1999, 2001). In particular, studies of apoptosis (programmed cell death) have shown that irradiation of Moor Frogs with ^{137}Cs at 5.57 R/min, the initial level of cell death for an animal, living on the contaminated territories (2.28±0.41) was almost twice that of a control group (1.12±0.41; $p < 0.03$).

It is necessary to note cases of bone tumors in some species of Anura that were, recorded in the initial period after the Chernobyl catastrophe (Voitovich, 2001). Presumably, the short-lived isotopes only influence the tumor formation, as the appearance of these anomalies was noted only in 1988 (i.e., the first 3 years after the beginning of the effects of this factor), and in subsequent samples they was not found.

It was also found that erythrocytes with microcores in the peripheral blood of the Common Frog tadpoles in contaminated territories are enlarged 3–4 times in comparison

with controls ($p<0.01$). For adult Moor and Common frogs, the hemopoiesis during summer almost stops. Therefore, all cytogenetic damages, in all probability, appear only in spring during the period of rapid erythropoiesis, and the microcores are formed during the last cell division (Voitovich, 2000). In the beginning of the studies in 1991, the number of erythrocytes with microcores from the contaminated territories of the region of Chernobyl exceeded the control by about 30 times. In subsequent years this parameter was decreased by 3–5 times ($p<0.05$–0.01).

The absence of any notable morphological anomalies in amphibians in the region of intensive radiation is explained, in all appearances, by the fact that animals with serious genetic, immunologic or biochemical abnormalities, as a rule, are not viable and fall out of the span of observation or are eliminated at larval, embryonic or oogenesis stages (Drobenkov et al., 2001).

Special ecological studies that were conducted with radius of 30 km from the Chernobyl Power Station presents evidence for the absence of serious differences in the structure of amphibian complexes in the territory most contaminated by radionuclides. It is possible to connect the main changes in the amphibian fauna of Polesskii Radio-Ecological Reserve, situated in the southeastern part of this region, with a decrease in human economic activities, eviction of the local population, and successions of plant communities. Species composition and structure in amphibian complexes of this natural region before the catastrophe and at present, by our data, remain typical for Pripyat Polesie.

The structure of amphibian communities in the region of intensive radioactive contamination, in Polesskii Radio-Ecological Reserve, based on the density of eurytopic, widely distributed species shows that green frogs (66.7–2687.5 specimens/ha), Fire-Bellied Toad (5.1–666.7) and Moor Frog (22.2–240.0) prevail. The density of populations of model amphibian species, selected with the purposes of long-term biological monitoring (*R. arvalis, R. esculenta* complex, *B. bombina, B. bufo, P. fuscus, B. viridis*), on the majority of plots of observations from 1986–1997 was at a stable level, and their fluctuations did not exceed usual seasonal and annual fluctuations. It is possible to connect changes in density of local populations of some amphibian species, observed in separate controlled habitats, with the successions of secondary swamping of modified lands, fast shrub invasion to dry and floodplain meadows, and gradual degradation of agricultural lands.

Unique ecological conditions, formed as a result of sharp decreases in the majority of anthropogenic factors and complete eviction of the local population from a considerable territory, are clearly reflected in the spatial distribution and number of amphibian populations of the majority of species. As a result, the numbers of the Moor Frog and the Common Toad have increased. Many species (*B. bufo, P. fuscus, H. arborea, T. vulgaris*) have dispersed into a wider spectrum of ecosystems and now occur in overgrown meadows, fields, kitchen gardens and in deserted villages. Numbers of the aquatic forms (*R. esculenta* complex, *B. bombina*) have dispersed into vast swamped areas. On the other hand, numbers of only one amphibian, the Green Toad, have clearly decreased.

Special collecting of amphibians from the territory of Belarus, conducted with different purposes at present seems to have a restricted character. Scientific studies and anatomical and physiological experiments in medical high schools and universities usually use the Common and the Moor frogs that are captured in small numbers in suburban zones of large cities. At the end of the 1980s and the first half of 1990s in the Byelorussian Polesie, several hundred Tree Frogs were collected by herpetologists for reintroduction of this species to Latvia where is has almost disappeared.

Amateur terrariumists, young naturalist societies and some schools most often keep Tree Frogs, Crested and Smooth newts, Green and Common toads and Spadefoots. Collecting of local amphibian species for commercial purposes has too small a scale to destroy their resources. In some markets (e.g., Storozhovsky Market in Minsk City), where animal trade is allowed, in the spring it is often possible to find very bright and attractive males of the Crested and the Smooth newts in nuptial color.

Many other anthropogenic factors, connected with economic or other human activities, also have harmful effect on the number of amphibians. In particular, cattle over-grazing, fast flooding of territories at building sites for reservoirs and ponds, cleaning of the bottom and shores of urban basins and drainage channels, intensive recreation, and some other forms of management produce negative effect on amphibians. However, the scales and degree of these effects on populations are not known because of the usual lack of appropriate methods of estimation.

7.2. Current State and Dynamics of Populations

Analysis of data on occurrence, density of populations and dynamics of distribution of particular amphibian species of on the territory of Belarus, as well as results of monitoring conducted from the beginning of 1980s in different regions of the Republic present evidence that in the last two decades the majority of monitored populations have not undergone visible changes and remain stable.

According to the results of these estimations, there are no species in a critical situation in Belarus that demands development of immediate conservation measures. However, apparently the lowest, more or less stable number is characteristic for the Byelorussian populations of the Natterjack Toad sporadically distributed in the southwestern, western and central parts of the Republic (i.e., provinces of Brest, Grodno and Minsk).

Breeding habitats of this species are shallow, warm basins mainly of anthropogenic origin: flooded sand pits, littoral zones of ponds, lakes and water storage basins, and separate parts of drainage channels. In connection with specificity of breeding pools (periodic filling, regular seasonal drying) the breeding success of the Natterjack Toad in many respects is determined by the level of summer precipitation. The stability of

Byelorussian groups of this species is, apparently, high breeding potential of the population which is connected with considerable breeding performance, possibility of repeated spawning, and a restricted spectrum of the competitors during larval development.

The Natterjack Toad is rare in the majority of countries of Central and Eastern Europe. In this connection, it was included in the Application II of the Bern Convention (i.e., demands special measures of conservation). In Belarus it is protected in national parks Belovezhskaya Pushcha (the main reserve for conservation of this species), Pripyatskii and the Beresinskii Biosphere Reserve. The small range of this small and vulnerable species is subject to extinction risk in nature, and it was included in the category VU (vulnerable species) of the third edition of the Red Data Book. The main threat to the existence of the Natterjack Toad is degradation and destruction of breeding habitats. Therefore, a special role in the conservation of its regional population pertains to the conservation of water bodies (groups of wetlands) with large breeding groups including about several hundred breeding individuals, as well as to special biotechnical measures to optimization breeding conditions.

According to recent data, the Crested Newt is distributed throughout the entire Republic but very sporadically (e.g., only in 2.9% of ecosystems). It was also included in the list of the rarest representatives of Byelorussian amphibians. The number of this species is low almost everywhere. In the last two decades a clear tendency to decline was noted, and the causes of this process are connected with the influence of anthropogenic factors.

Crested Newt also are rare in many countries of Europe, and in this connection is was included in the IUCN Red List in the category LR:cd (Lower Risk: conservation dependent) and in the Application II of the Bern Convention (requires special measures of conservation). In Belarus, it occurs in all national parks and nature reserves. However, practically everywhere (excluding Pripyatskii National Park) it is very rare. In connection with the change of the nature protection status, this species is proposed for inclusion in the lists of the 3rd edition of the Red Data Book of Belarus in the category LR:nt (Lower Risk: near threatened).

The Edible Frog belongs to a category of species with unclear status whose geographical distribution and ecology in the Republic, as well as in many other parts of the range, are almost unknown. In spite of the fact that there is only one locality of this species known exactly (in Nesvizhskii District of Minskaya Province), it is possible to assume that it is a typical member of the Byelorussian fauna. Estimations of its status is complicated by the difficulty of exact species identification.

Two other amphibians, not included in the main "group of risk" (i.e., Tree Frog and Fire-Bellied Toad) include species with narrow distributions but with large populations. These require permanent monitoring, in particular, of the populations at the edge of their geographical ranges. Common and Green toads seem to belong to the same group. Their skin secretions may have practical value, but measures of sustainable use of their populations were not elaborated.

Long-term dynamics and conservation status of geographical populations of rare and vulnerable amphibian species should be studied in different natural regions of Belarus which differ by

landscape-ecological structure and intensity of economic usage. The populations from central and southern parts (e.g., provinces of Minsk, Gomel and Brest) seem to have the largest anthropogenic pressures. The least negative effect is experienced by populations in the northern region (Vitebskaya Province) where the least transformed natural landscapes remain.

Anthropogenic factors play a leading role in population declines of many amphibian species, but in particular localities, the dynamics of their populations can be connected with such natural factors such as vegetative successions and increase of water eutrophication.

When estimating the dynamics of faunistic complexes of amphibians, it is necessary to note that the greatest anthropogenic pressure falls, in all probability, on riparian and meadow amphibian complexes with highest species diversity and population density. They undergo the most intensive transformation for agricultural use and recreation. Complexes of amphibians of wood and swamp ecosystems suffer lower pressures.

7.3. Measures of Conservation

In spite of the relatively good condition of the batrachofauna of Belarus, it is absolutely clear that in the near future existing protective measures will be completely insufficient for the conservation of this group. Such perspectives are determined not only by the increase of the scales and intensification of all types of human economic activities in the Republic during recent decades, but also by the appearance of new forms of anthropogenic transformation of natural landscapes.

The spectrum of measures directed at the conservation of the fauna in Belarus includes normative and territorial measures. The law on conservation and use of fauna, as in the majority of other countries, has a generally directive character. Other form of conservation, territorial, is effective enough, but the areas of Belarus allotted for this aim are in most cases connected with conservation of unique natural complexes or especially valuable animal species (e.g., European Bison or Beaver). High biological diversity of amphibians the system of protected territories of Belarus is indicative only for one reserve, Pripyatskii National Park, which is situated in Polesie in the central part of the Pripyat river basin.

Only relatively small networks of territories are protected (e.g., national parks, nature reserves and natural sanctuaries). With reference to amphibians, in our opinion, the most effective form of protection is the reservation of small areas (i.e., creation of natural sanctuaries notable for high richness in species, intact multispecific communities, high number of rare species, or specific morphogenetic composition of populations).

Numerous fisheries, which have great areas of protected shallow-water ponds optimal for breeding in many species (*R. esculenta* complex, *H. arborea, B. bombina, P. fuscus, B. bufo,* and *B. viridis*) may also be considered as specially protected because they are able to play an important role in the conservation of amphibian biological diversity.

In connection with the fact that the spatial structure of amphibian populations is connected mainly with hydrological factors, the key problems of nature protection measures, directed on protection and regeneration of their populations, should be conservation of water bodies serving as habitats for egg deposition and embryonic and larval development. The destruction of breeding habitats is the main cause of amphibian decline in anthropogenic landscapes. The necessity of protection of pools is determined also by the fact that during the mating season large parts of the adult population is gathered, and some species hibernate there. The mass aggregations of animals on a local area make them especially vulnerable.

Numerous observations of the state of local groups of different species of amphibians (e.g., *B. calamita, T. cristatus, R. temporaria, R. arvalis, B. viridis,* and *P. fuscus*) have shown that in favorable conditions, because of their high breeding performance, their numbers during 1–2 breeding seasons can increase many times and create a basis for existence of stable populations. Observations on the breeding of Natterjack Toad in artificial ponds (sand pits) have shown that 3–4 pairs of toad in good weather give rise to a new generation with 1500–2500 metamorphs. The fast growth of amphibian micropopulations in favorable conditions is typical also for other species, which is evidence for the high efficiency of biotechnical measures directed to their protection (Fig. 48). Conservation or special

Fig. 48. *Bufo viridis* sanctuary places in Minsk City.

establishment of small ponds in the regions of land reclamation, urbanization or recreation will allow amphibians to survive.

An important direction of amphibian protection is the development of special road-building measures for avoidance of their loss on motorways with intensive traffic, in particular, in the season of their mass migrations to the sites of breeding and hibernation. Building of directing fences and small tunnels in low places may be effective.

One of the actual approaches to conservation of natural populations of rare or threatened species of amphibians is their artificial rearing with the purposes of further reintroduction.

Special education activities directed on popularization of ecology and biology of these animals plays a great positive role in their conservation. According to questionnaires in urban and rural areas, the state of amphibian fauna is determined quite often by the attitude of the people. Because of widespread incorrect views, the absence of basic knowledge and, sometimes, low ecological culture, a considerable proportion of people have a negative attitude toward amphibians. Contrary to the majority of other vertebrates, amphibians have a low mobility, which makes them accessible to people, and in the places of their mass concentration (especially in breeding season) one can quite often find dozens of amphibians which have been killed senselessly by people. In this connection, conservation of amphibians would be promoted by educational measures (e.g., ecological camps and programs on TV and radio), popular lectures, and printing of booklets (Fig. 49 and 50).

Fig. 49. Excursion for pupils studying amphibian life and conservation.

Fig. 50. (A and B) Research on amphibian censuses and conservation on the Berezina River.

CONCLUSIONS

This book is based on numerous investigations of different aspects of the ecology, morphology and ethology of amphibians collected during the last twenty years within Belarus. These data display the primary results and problems which may be resolved in the future.

The general analysis of data indicates the presence of a high level of variability of amphibian population structure on a relatively small area in Eastern Europe. Heterogeneity of amphibian association structure depends on a mosaic of nature complexes and the dynamic of anthropogenic transformation of the region.

Our investigations demonstrate the high level of sensitivity of amphibians to different natural and anthropogenic factors. They adapt to dynamic of different factors by changing population and assemblage structure.

Long-term zoological monitoring is of great scientific interest. These studies began in the 1980s. This kind of estimation will allow a deep analysis and forecast the dynamics of population structure in the near future. Numerous data on geographical distribution and habitat preferences and dynamics and population structure provide an ability to form databases which play a role as the basis of land taxation and biological control.

Modern knowledge of the Byelorussian batrachofauna needs additional investigations in paleontology and systematics because historically the Byelorussian herpetological school had ecological and morphological directions of research. Active investigations are done in the methodology of active and passive protection. Some complicated questions of systematics and adaptation of amphibians to condition of the environment are developed in cooperation with colleagues from adjacent countries. At present, such cooperation includes investigations of population structure and hybrid complexes of green frogs and the taxonomic status of the Spadefood Toad. Amphibian adaptations to condition of settlements, big cites and agricultural lands are also under study.

Nevertheless, many interesting questions and directions of research are missed by virtue of the absence of specialists. In particular, this is true with the amphibian role in ecosystems as consumers. At present, the methodology of exploitation of natural and semi-natural populations for pharmacological and food industries is starting.

The latest data show relatively stable numbers of amphibians. The majority of populations display fluctuations based on environmental conditions. In particular, the dynamics of

the main critical factors (i.e., breeding success, rainfall patterns, and dynamics of optimal climate conditions during the summer, and hibernation) can determine the primary patterns.

At present, most problems associated with amphibian protection are conservation measures in areas of intensive agriculture. The main thrust in the near future should address the reserving of the most valuable areas for some amphibian species or associations where these populations are living and have stable population numbers. Protection and restoration of breeding ponds, protection of amphibians with conservation of habitats, including all important components of the environment at all stages of the life cycle, is one of the important tasks.

List of Sites and Structure of Amphibian Associations

Province centers	District centers	Localities	Types of localities	Additional data on localities	Number of species in localities	*Bombina bombina*	*Bufo bufo*	*Bufo calamita*	*Bufo viridis*	*Hyla arborea*	*Pelobates fuscus*	*Rana arvalis*	*Rana esculenta*	*Rana lessonae*	*Rana ridibunda*	*Rana temporaria*	*Triturus cristatus*	*Triturus vulgaris*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Brest	Baranovichi	Lesnaya	railway station	1 km east	1											+		
Brest	Baranovichi	Tartaki	village		4		+					+				+		+
Brest	Bereza	Beloozersk	city		2		+						+					
Brest	Bereza	Bereza	urban village		1				+									
Brest	Bereza	Bereza	urban village	river Yaselda	3		+				+		+					
Brest	Bereza	Bolshie Matveevichi	village		2		+					+						
Brest	Bereza	Vysokoe	village	river Yaselda	1								+					
Brest	Bereza	Zditovo	village		1							+						
Brest	Bereza	Matveevichi	village	river Yaselda	4			+		+	+		+					
Brest	Bereza	Novye Peski	village		7	+	+		+	+		+	+			+		
Brest	Bereza	Selets	village	3 km north	2	+							+					
Brest	Bereza	Selets	village	3.6 km north	2							+	+					
Brest	Bereza	Selets	village	4.2 km north	3	+						+	+					
Brest	Bereza	Sporovo	village	lake Sporovo	1				+									
Brest	Bereza	Starye Peski	village		5	+	+				+	+		+				
Brest	Bereza	Strigin	village		1				+									
Brest	Bereza	Strigin	village	river Yaselda	7		+	+	+	+	+	+	+					
Brest	Brest	Gvoznitsa	village		1				+									
Brest	Brest	Medno	village		11	+	+	+	+	+	+	+	+			+	+	+
Brest	Brest	Medno	village	2 km north	2					+								+
Brest	Gantsevichi	Borki	village	3.5 km northwest	1							+						
Brest	Gantsevichi	Borki	village	4 km northwest	1								+					
Brest	Gantsevichi	Vygonoshchanskoe	lake	4 km south	4					+	+	+	+					
Brest	Gantsevichi	Gantsevichi	city		2							+	+					
Brest	Gantsevichi	Laktyshi	village		2							+	+					
Brest	Gantsevichi	Ozero	village	1 km south	1								+					
Brest	Gantsevichi	Razdyalovichi	village		4					+		+	+			+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Brest	Gantsevichi	Rozdyalovichi	village		3		+					+	+					
Brest	Gantsevichi	Hotynichi	village		2							+	+					
Brest	Drogichin	Zarechki	village		1				+									
Brest	Drogichin	Zarechki	village	Dnepro-Bugsky Channel	2							+	+					
Brest	Ivanovo	Ivanovo	city		1				+									
Brest	Ivanovo	Kokoritsa	village		2						+	+						
Brest	Ivanovo	Opol	village		2						+	+						
Brest	Ivanovo	Opol	village	10 km north	1		+											
Brest	Ivatsevichi	Byten	village		2	+		+										
Brest	Ivatsevichi	Vygonoshchanskoe	lake	4 km south	1	+												
Brest	Ivatsevichi	Vygonoshchi	village		1					+								
Brest	Kamen	Volchin	village		3				+			+	+					
Brest	Kamen	Kamenyuki	village		9		+	+	+	+	+	+	+			+		+
Brest	Kobrin	Kobrin	city		4	+	+					+	+					
Brest	Luninets	Galyi Bor	village		7	+	+			+		+				+	+	+
Brest	Luninets	Kozhan-Gorodok	village		6	+				+	+	+	+			+		
Brest	Luninets	Polesskii	village		5	+	+					+	+			+		
Brest	Luninets	Senkeviches	village	2 km east	1			+										
Brest	Luninets	Senkeviches	village	2.5 km south	4			+				+	+			+		
Brest	Luninets	Sinkevichi	village		7		+	+		+	+	+	+			+		
Brest	Luninets	Sinkevichi	village	2.5 km south	1						+							
Brest	Luninets	Senkevichi	village	river Lan	1	+												
Brest	Lyakhovichi	Gonchary	village	1 km north	2							+				+		
Brest	Lyakhovichi	Medvedichi	village	0.2 km west	1							+						
Brest	Lyakhovichi	Medvedichi	village	1 km south	1													+
Brest	Malorita	Boguslavka	village	1 km south	1								+					
Brest	Malorita	Boguslavka	village	1.2 km south	1								+					
Brest	Malorita	Gvoznitsa	village		7		+		+	+	+	+	+			+		
Brest	Malorita	Gusak	village		1							+						
Brest	Malorita	Zburazh	village		2			+	+									
Brest	Malorita	Mokrany	village		4			+	+			+	+					
Brest	Malorita	Ryta	river		2							+				+		
Brest	Pinsk	Bolshaya Vulka	village		4	+					+		+			+		
Brest	Pinsk	Lasitsk	village		4	+	+					+	+					

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Brest	Pinsk	Lemeshevichi	village		3	+					+	+						
Brest	Pinsk	Malaya Vulka	village		1			+										
Brest	Pinsk	Malaya Vulka	village	1 km north	1				+									
Brest	Pinsk	Pinsk	city		3	+						+	+					
Brest	Pinsk	Tereben	village		1	+												
Brest	Pinsk	Chernovo	village		3						+	+	+					
Brest	Pruzhany	Borki	village		1											+		
Brest	Pruzhany	Guta	village	1.9 km west	1											+		
Brest	Pruzhany	Guta	village	2.3 km south-west	2								+			+		
Brest	Pruzhany	Guta	village	2.5 km northeast	11	+	+	+	+	+	+	+	+			+	+	+
Brest	Pruzhany	Novyi Dwor	village		2							+	+					
Brest	Pruzhany	Pruzhanovichi	village		1		+											
Brest	Pruzhany	Trukhanovichi	village		2							+				+		
Brest	Pruzhany	Trukhanovichi	village	1.2 km north	1							+						
Brest	Pruzhany	Trukhanovichi	village	2 km north	1							+						
Brest	Pruzhany	Trukhanovichi	village	2.6 km north	1											+		
Brest	Pruzhany	Trukhanovichi	village	2.8 km north	2							+	+					
Brest	Pruzhany	Trukhanovichi	village	4.5 km east	3	+							+			+		
Brest	Pruzhany	Yuzefin	khutor		6	+	+		+				+			+		+
Brest	Pruzhany	Yuzefin	khutor	2.5 km southeast	1			+										
Brest	Pruzhany	Yuzefin	khutor	2.7 km southeast	1							+						
Brest	Pruzhany	Yuzefin	khutor	3.5 km southeast	1							+						
Brest	Pruzhany	Yuzefin	khutor	4 km southeast	1							+						
Brest	Pruzhany	Yaselda	river		1											+		
Brest	Slonim	Akachi	village	2 km north.-west	2					+						+		
Brest	Slonim	Konjushany	village	2 km southeast	1							+						
Brest	Stolin	Bakovo	village	1 km southwest	1							+						
Brest	Stolin	Bakovo	village	2 km north	2	+							+					
Brest	Stolin	Bakovo	village	2 km southwest	1							+						
Brest	Stolin	Bakovo	village	2.5 km east	2	+							+					
Brest	Stolin	Bakovo	village	2.5 km northwest	1							+						
Brest	Stolin	Bakovo	village	2.6 km west	2					+			+					
Brest	Stolin	Bakovo	village	2.7 km west	3		+					+	+					
Brest	Stolin	Bakovo	village	2.7 km north	3					+		+	+					

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Brest	Stolin	Bakovo	village	3 km north	3		+				+	+						
Brest	Stolin	Bakovo	village	3 km southwest	1							+						
Brest	Stolin	Bakovo	village	3 km south	2					+		+						
Brest	Stolin	Bakovo	village	3.4 km south	2							+	+					
Brest	Stolin	Bakovo	village	4 km north	1								+					
Brest	Stolin	Bereztsy	village		5	+					+	+	+			+		
Brest	Stolin	David-Gorodok	urban village		9	+	+	+	+	+	+	+	+			+		
Brest	Stolin	Dubok	village		1		+											
Brest	Stolin	Lan	river		1							+						
Brest	Stolin	Lasitsk	village	2 km north	3	+						+	+					
Brest	Stolin	Olmany	village		1		+											
Brest	Stolin	Olmany	village	5 km east	1		+											
Brest	Stolin	Olshany	village		1								+					
Brest	Luninets	Senkevichi	village	river Lan	1								+					
Brest	Stolin	Stolin	city		2							+	+					
Brest	Stolin	Stolin	city	8 km southeast	1							+						
Brest	Stolin	Turets	village		1		+											
Brest	Stolin	Turets	village		1	+												
Brest	Stolin	Horsk	village		6	+	+					+	+				+	+
Vitebsk	Dokshitsy	Berezina	river		1											+		
Vitebsk	Beshenkovichi	Bui	village		3		+	+										
Vitebsk	Beshenkovichi	Koranevskoe	lake		3		+					+				+		
Vitebsk	Beshenkovichi	Porechie	village	river Zapadnaya Dvina	2							+				+		
Vitebsk	Beshenkovichi	Holny	village	2 km east	1		+											
Vitebsk	Beshenkovichi	Holny	village	2 km south	2		+									+		
Vitebsk	Beshenkovichi	Holny	village	3 km south	2		+									+		
Vitebsk	Braslav	Vazha	lake		2		+									+		
Vitebsk	Braslav	Drisvyaty	village		1							+						
Vitebsk	Braslav	Drisvyaty	village	lake Drisvyaty	1		+											
Vitebsk	Braslav	Pashevichi	village		4		+				+	+				+		
Vitebsk	Braslav	Fedosovshchina	village	2 km east	1		+											
Vitebsk	Braslav	Southern Volos	lake		1							+						
Vitebsk	Verhnedvinsk	Verhnedvinsk	city		2		+	+										
Vitebsk	Verhnedvinsk	Drissa	river		1											+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Vitebsk	Verhnedvinsk	Leonpol	village		2							+				+		
Vitebsk	Verhnedvinsk	Lisno	village		1							+						
Vitebsk	Verhnedvinsk	Osveiskoe	lake		3		+					+				+		
Vitebsk	Verhnedvinsk	Osveya	lake		4							+	+			+		+
Vitebsk	Verhnedvinsk	Sukoli	village		6		+				+	+	+			+		+
Vitebsk	Vitebsk	Vitebsk	city		1				+									
Vitebsk	Vitebsk	Gorodnoe	village		3		+	+										
Vitebsk	Vitebsk	Kon'ki	village		2							+				+		
Vitebsk	Vitebsk	Kon'ki	village	river Zapadnaya Dvina	10		+		+		+	+	+			+	+	+
Vitebsk	Vitebsk	Krupodery	village		7		+		+		+	+				+		+
Vitebsk	Glubokoe	Hroly	village		1		+											
Vitebsk	Glubokoe	Sho	lake		1							+						
Vitebsk	Gorodok	Vodobarka	village	1 km south	1								+					
Vitebsk	Gorodok	Vymno	lake		3						+	+				+		
Vitebsk	Gorodok	Ezerishche	urban village		1							+						
Vitebsk	Gorodok	Ezerishche	urban village	2 km north	1							+						
Vitebsk	Gorodok	Ezerishche	urban village	2 km south	1							+						
Vitebsk	Gorodok	Ezerishche	urban village	2.4south	2							+				+		
Vitebsk	Gorodok	Zaluchie	village	2.5 km east	1											+		
Vitebsk	Gorodok	Zaluchie	village	2.5 km northeast	1											+		
Vitebsk	Gorodok	Kosho	lake		1							+						
Vitebsk	Gorodok	Kosho	lake	0.5 km east	2							+				+		
Vitebsk	Gorodok	Kosho	lake	3 km east	3		+					+				+		
Vitebsk	Gorodok	Losvido	lake		1							+						
Vitebsk	Gorodok	Pogost	village	lake Kosho	1		+											
Vitebsk	Gorodok	Surmino	village	1 km south	1											+		
Vitebsk	Gorodok	Usysa	river		1							+						
Vitebsk	Dokshitsy	Berezino	village	3 km south	1											+		
Vitebsk	Dokshitsy	Berezino	village	3 km south	1		+											
Vitebsk	Dokshitsy	Berezino	village	river Berezina	2		+									+		
Vitebsk	Dokshitsy	Sloboda	village		3		+		+			+						
Vitebsk	Dubrovno	Dubrovno	city		1							+						
Vitebsk	Dubrovno	Osintorf	urban village	1.5 km north.-west	2							+						+
Vitebsk	Dubrovno	Osintorf	urban village	1.9 km north.-west	1		+											

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Vitebsk	Dubrovno	Osintorf	urban village	3 km east	3		+					+				+		
Vitebsk	Lepel	Mostische	village	1 km north	1		+											
Vitebsk	Lepel	Mostische	village	3 km south	3		+					+				+		
Vitebsk	Lepel	Mostische	village	river Berezina	3		+					+				+		
Vitebsk	Lepel	Gora Volova	village		1		+											
Vitebsk	Lepel	Domzheritsy	settlement		8		+		+		+	+	+	+		+		+
Vitebsk	Lepel	Domzheritsy	settlement	1 km northwest	2							+				+		
Vitebsk	Lepel	Domzheritsy	settlement	1.2 km northwest	3				+				+					+
Vitebsk	Lepel	Domzheritsy	settlement	1.3 km southwest	1											+		
Vitebsk	Lepel	Domzheritsy	settlement	1.5 km south	1							+						
Vitebsk	Lepel	Domzheritsy	settlement	1.8 km southwest	1							+						
Vitebsk	Lepel	Kvedcha	village		3		+					+				+		
Vitebsk	Lepel	Kvedcha	village	0.5 km west	1							+						
Vitebsk	Lepel	Kraitsy	village		6		+		+		+	+				+		+
Vitebsk	Lepel	Kraitsy	village	1 km west	1											+		
Vitebsk	Lepel	Kraitsy	village	2 km east	1		+											
Vitebsk	Lepel	Kraitsy	village	Serguchsky Channel	2							+				+		
Vitebsk	Lepel	Mostishche	tract	river Berezina	2		+									+		
Vitebsk	Lepel	Postrezhie	village		2							+				+		
Vitebsk	Lepel	Postrezhie	tract		1		+											
Vitebsk	Lepel	Postrezhie	village	0.4 km south	1											+		
Vitebsk	Lepel	Postrezhie	village	1 km east	2							+				+		
Vitebsk	Lepel	Postrezhie	village	1.3 km south	1							+						
Vitebsk	Lepel	Postrezhie	village	2 km northwest	3		+					+				+		
Vitebsk	Lepel	Postrezhie	village	2 km south	1							+						
Vitebsk	Lepel	Savskii Bor	village		4		+		+			+				+		
Vitebsk	Lepel	Savskii Bor	village	12 km northwest	1											+		
Vitebsk	Lepel	Savskii Bor	village	2.8 km east	2							+				+		
Vitebsk	Lepel	Savskii Bor	village	river Berezina	1		+											
Vitebsk	Lepel	Uborok	village		1							+						
Vitebsk	Lepel	Uborok	village	5 km east	3		+					+				+		
Vitebsk	Lepel	Chernichino	tract		2		+									+		
Vitebsk	Miory	Dvina	urban village		2		+		+									
Vitebsk	Miory	Disna	urban village		1				+									

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Vitebsk	Miory	Yelnya	tract		3		+					+				+		
Vitebsk	Miory	Leonpol	village		3		+		+							+		
Vitebsk	Miory	Mazulino	village		1				+									
Vitebsk	Miory	Nobisto	lake		1							+						
Vitebsk	Miory	Obsterno	lake		1							+						
Vitebsk	Miory	Perebrodie	village		2		+					+						
Vitebsk	Miory	Fedosovshchina	village	2 km east	5		+		+			+		+		+		
Vitebsk	Orsha	Lisuny	village		1				+									
Vitebsk	Orsha	Smetanki	village		2				+							+		
Vitebsk	Orsha	Ustie	village		1							+						
Vitebsk	Orsha	Himy	village		1				+									
Vitebsk	Polotsk	Gvozdevo	village	river Zapadnaya Dvina	1		+											
Vitebsk	Polotsk	Glinishche	village	1 km northeast	1											+		
Vitebsk	Polotsk	Gorovaya	village		5		+		+			+				+		
Vitebsk	Polotsk	Zalyukhovo	village	1 km north	2				+							+		
Vitebsk	Polotsk	Zalyukhovo	village	1.5 km northwest	2							+				+		
Vitebsk	Polotsk	Karpinichi	village		3				+			+				+		
Vitebsk	Polotsk	Karpinichi	village	1 km east	2							+				+		
Vitebsk	Polotsk	Karpinichi	village	river Zapadnaya Dvina	1											+		
Vitebsk	Polotsk	Litvinovka	village		1				+									
Vitebsk	Polotsk	Litvinovo	village		1		+											
Vitebsk	Polotsk	Litvinovo	village	river Zapadnaya Dvina	2							+				+		
Vitebsk	Polotsk	Luchno	village		1							+						
Vitebsk	Polotsk	Novopolotsk	city		4				+			+				+		+
Vitebsk	Polotsk	Novopolotsk	city	2 km south	2							+				+		
Vitebsk	Polotsk	Polotsk	city		1				+									
Vitebsk	Polotsk	Ekiman	village		1							+						
Vitebsk	Rossony	Gorbachevo	village	2 km east	1											+		
Vitebsk	Rossony	Gorbachevo	village	2.4 km east	2							+				+		
Vitebsk	Rossony	Gorbachevo	village	2.8 km east	2							+				+		
Vitebsk	Rossony	Gorbachevo	village		1							+						
Vitebsk	Rossony	Rossony	lake		1							+						
Vitebsk	Senno	Senno	village		1							+						
Vitebsk	Tolochin	Zamoshje	village		1				+									

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Vitebsk	Tolochin	Kohanovo	village		2							+				+		
Vitebsk	Ushachi	Glybochki	village		1											+		
Vitebsk	Ushachi	Glybochki	village		1							+						
Vitebsk	Ushachi	Otolovo	lake		1							+						
Vitebsk	Ushachi	Turospolie	village	river Ditva	2				+			+						
Vitebsk	Sharkovshchina	Buda	village		1							+						
Vitebsk	Sharkovshchina	Chornoe	lake		1							+						
Vitebsk	Sharkovshchina	Gribly	village		1	+												
Vitebsk	Shumilino	Kamenka	village		1				+									
Vitebsk	Shumilino	Poltevo	village	river Zapadnaya Dvina	2							+				+		
Vitebsk	Shumilino	CherniChino	village		2		+											+
Vitebsk	Shumilino	Chernichino	village		1		+											
Vitebsk	Shumilino	Cherchitsy	village		4		+				+	+				+		
Gomel	Bragin	Asarevichi	village		2	+	+											
Gomel	Bragin	Asarevichi	village	0.4 km east	2							+	+					
Gomel	Bragin	Asarevichi	village	1 km east	4	+				+		+	+					
Gomel	Bragin	Asarevichi	village	2 km east	1							+						
Gomel	Bragin	Babchin	village	2 km east	2							+	+					
Gomel	Bragin	Verkhnie Zhary	village		2								+			+		
Gomel	Bragin	Glukhovichi	village		4				+		+	+		+				
Gomel	Bragin	Dronki	village	1.5 km east	3								+				+	+
Gomel	Bragin	Krasnye Gory	village		4				+		+	+		+				
Gomel	Bragin	Orevichi	village	1 km east	2							+	+					
Gomel	Bragin	Orevichi	village	2 km east	1								+					
Gomel	Gomel	Klin	village	1 km west	1								+					
Gomel	Gomel	Klin	village	3 km east	1								+					
Gomel	Gomel	Sharpilovka	village		2		+		+									
Gomel	Gomel	Sharpilovka	village	1 km south	1							+						
Gomel	Gomel	Sharpilovka	village	2 km north	3						+	+	+					
Gomel	Zhitkovichi	Borki	village		1				+									
Gomel	Zhitkovichi	Borovaya	village		3							+		+	+			
Gomel	Zhitkovichi	Borovaya	village	fishery Beloe	7	+	+		+	+	+	+			+			
Gomel	Zhitkovichi	Bronislav	village		6	+				+	+	+	+			+		
Gomel	Zhitkovichi	Veresnitsa	village	2 km west	1								+					

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Gomel	Zhitkovichi	Lyahovichi	village	lake Chervonoe	1						+							
Gomel	Zhitkovichi	Ozerany	village		2							+				+		
Gomel	Zhitkovichi	Turov	urban village		1					+								
Gomel	Zhitkovichi	Turov	urban village		6	+	+		+		+	+	+					
Gomel	Zhitkovichi	Turov	urban village	natural boundary Gleboboris	1								+					
Gomel	Zhitkovichi	Turov	urban village	natural boundary Kandarovka	3								+				+	+
Gomel	Zhitkovichi	Khvoensk	village		6		+					+	+			+	+	+
Gomel	Zhitkovichi	Khvoensk	village		7	+	+		+	+	+	+			+			
Gomel	Zhitkovichi	Khvoensk	village	0.3 km east	3							+					+	+
Gomel	Zhitkovichi	Khvoensk	village	1 km east	9		+		+	+	+	+	+			+	+	+
Gomel	Zhitkovichi	Khvoensk	village	1 km west	1							+						
Gomel	Zhitkovichi	Khvoensk	village	1 km northeast	6	+				+	+	+	+					+
Gomel	Zhitkovichi	Khvoensk	village	1 km southwest	3							+	+				+	
Gomel	Zhitkovichi	Khvoensk	village	1 km south	2							+	+					
Gomel	Zhitkovichi	Khvoensk	village	1.5 km northeast	1							+						
Gomel	Zhitkovichi	Khvoensk	village	1.5 km southeast	2							+	+					
Gomel	Zhitkovichi	Khvoensk	village	1.8 km ves.-east	1							+						
Gomel	Zhitkovichi	Khvoensk	village	2 km east	2		+					+						
Gomel	Zhitkovichi	Khvoensk	village	2 km north	3		+					+				+		
Gomel	Zhitkovichi	Khvoensk	village	2 km northeast	3	+						+	+					
Gomel	Zhitkovichi	Khvoensk	village	2 km southeast	3	+						+	+					
Gomel	Zhitkovichi	Khvoensk	village	2.5 km south	2							+					+	
Gomel	Zhitkovichi	Khvoensk	village	2.9 km northeast	1							+						
Gomel	Zhitkovichi	Khvoensk	village	3 km west	4	+	+					+	+					
Gomel	Zhitkovichi	Khvoensk	village	3 km west	3					+		+	+					
Gomel	Zhitkovichi	Khvoensk	village	3 km southeast	1							+						
Gomel	Zhitkovichi	Khvoensk	village	3 km southwest	4	+				+		+	+					
Gomel	Zhitkovichi	Khvoensk	settlement	3 km southwest	1				+									
Gomel	Zhitkovichi	Khvoensk	village	3 km south	3		+					+	+					
Gomel	Zhitkovichi	Khvoensk	settlement	3 km south	2					+		+						
Gomel	Zhitkovichi	Khvoensk	settlement	3.2 km southwest	1								+					
Gomel	Zhitkovichi	Khvoensk	settlement	3.2 km south	2							+	+					
Gomel	Zhitkovichi	Khvoensk	village	5 km south	1							+						
Gomel	Zhitkovichi	Khvoensk	settlement	5 km south	2							+	+					

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Gomel	Zhitkovichi	Khlupin	village		8	+	+		+		+	+	+		+	+		
Gomel	Zhitkovichi	Khlupin	village	0.6 km south	1								+					
Gomel	Zhitkovichi	Khlupin	village	1 km north	3	+						+	+					
Gomel	Zhitkovichi	Khlupin	village	1 km south	4	+					+	+	+					
Gomel	Zhitkovichi	Khlupin	village	1.4 km south	1							+						
Gomel	Zhitkovichi	Khlupin	village	1.9 km south	1							+						
Gomel	Zhitkovichi	Khlupin	village	2 km south	2		+					+						
Gomel	Zhitkovichi	Khlupin	village	2.3 km southeast	1							+						
Gomel	Zhitkovichi	Khlupin	village	2.3 km south	1								+					
Gomel	Zhitkovichi	Khlupin	village	2.4 km east	1							+						
Gomel	Zhitkovichi	Khlupin	village	2.5 km east	1							+						
Gomel	Zhitkovichi	Khlupin	village	2.7 km east	1							+						
Gomel	Zhitkovichi	Khlupin	village	3 km west	3					+	+	+						
Gomel	Zhitkovichi	Khlupin	village	3 km north	1		+											
Gomel	Zhitkovichi	Khlupin	village	3 km north	1						+							
Gomel	Zhitkovichi	Khlupin	village	3 km southeast	2		+					+						
Gomel	Zhitkovichi	Khlupin	village	3 km south	2		+					+						
Gomel	Zhitkovichi	Khlupin	village	3.5 km west	2		+					+						
Gomel	Zhitkovichi	Khlupin	village	3.5 km southeast	2		+					+						
Gomel	Zhitkovichi	Khlupin	village	3.5 km south	1							+						
Gomel	Zhitkovichi	Khlupin	village	3.7 km south	1							+						
Gomel	Zhitkovichi	Khlupin	village	3.9 km south	1							+						
Gomel	Zhitkovichi	Khlupin	village	4 km east	2		+					+						
Gomel	Zhitkovichi	Khlupin	village	4 km southeast	2		+					+						
Gomel	Zhitkovichi	Khlupin	village	4 km south	4	+	+					+	+					
Gomel	Zhitkovichi	Khlupin	village	river Pripyat	1							+						
Gomel	Zhitkovichi	Chervonoe	lake		3							+	+			+		
Gomel	Zhlobin	Krasnoberezhie	village	3 km west	1							+						
Gomel	Zhlobin	Nizhnyaya Olba	village		2								+			+		
Gomel	Kalinkovichi	Yurovichi	village	2.5 km east	1							+						
Gomel	Lelchitsy	Bujnovichi	village		1		+											
Gomel	Lelchitsy	Bujnovichi	village	1 km north	1							+						
Gomel	Lelchitsy	Bujnovichi	village	2 km north	1								+					
Gomel	Lelchitsy	Bujnovichi	village	3 km north	1								+					

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Gomel	Lelchitsy	Domzheritsy	settlement		1				+									
Gomel	Lelchitsy	Zamoshie	village		1				+									
Gomel	Lelchitsy	Lelchitsy	city		8	+	+		+	+		+		+			+	+
Gomel	Lelchitsy	Manchitsy	village		2							+				+		
Gomel	Lelchitsy	Milashevichi	village		4	+	+			+						+		
Gomel	Lelchitsy	Milashevichi	village	1 km east	1					+								
Gomel	Lelchitsy	Milashevichi	village	4 km east	2						+	+						
Gomel	Lelchitsy	Milashevichi	village	1 km east	2							+				+		
Gomel	Lelchitsy	Milashevichi	village	2 km south	1							+						
Gomel	Lelchitsy	Ostrozhanka	village		1					+								
Gomel	Lelchitsy	Ostrozhanka	village		2				+							+		
Gomel	Lelchitsy	Ostrozhanka	village	3 km south	6	+	+			+	+		+			+		
Gomel	Lelchitsy	Rudnya	village		2							+				+		
Gomel	Lelchitsy	Simonichi	village		4								+			+	+	+
Gomel	Lelchitsy	Simonichskaya Rudnya	village	2 km east	1							+						
Gomel	Lelchitsy	Simonichskaja Rudnya	village	2.5 km east	1								+					
Gomel	Lelchitsy	Ubortskaya Rudnya	village		5		+		+			+	+					+
Gomel	Lelchitsy	Ubortskaya Rudnya	village	3 km north	2							+	+					
Gomel	Lelchitsy	Ubortskaya Rudnya	village	4 km north	2							+	+					
Gomel	Lelchitsy	Shok	village		1				+									
Gomel	Lelchitsy	Khvoensk	village		1					+								
Gomel	Loev	Loev	urban village		2								+			+		
Gomel	Loev	Loev	urban village	2 km east	4	+						+	+			+		
Gomel	Mozyr	Kostyukovichi	city		3							+	+			+		
Gomel	Mozyr	Kostyukovichi	city	1 km southeast	2	+							+					
Gomel	Mozyr	Kostyukovichi	city	1 km south	3		+				+	+						
Gomel	Mozyr	Kostyukovichi	city	1.4 km south	1							+						
Gomel	Mozyr	Kostyukovichi	city	1.6 km south	1							+						
Gomel	Mozyr	Kostyukovichi	city	1.8 km south	1							+						
Gomel	Mozyr	Mozyr	city		2								+			+		
Gomel	Mozyr	Mozyr	city	3 km east	2							+	+					
Gomel	Mozyr	Turgovichi	village	river Pripyat	1						+							
Gomel	Narovlya	Dernovichi	village	river Pripyat	3	+						+	+					
Gomel	Narovlya	Karpovichi	village		2						+	+						

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Gomel	Narovlya	Karpovichi	village	3 km east	1						+							
Gomel	Narovlya	Narovlya	city		3							+	+			+		
Gomel	Narovlya	Slovechna	estuary of river	3	+						+	+						
Gomel	Narovlya	Teshkov	village		2						+	+						
Gomel	Narovlya	Teshkov	village	5 km southeast	3		+				+	+						
Gomel	Petrikov	Belanovichi	village		3		+	+	+									
Gomel	Lelchitsy	Bujnovichi	village	4 km north	2							+	+					
Gomel	Petrikov	Konkovichi	village		1								+					
Gomel	Petrikov	Konkovichi	village	1 km east	1							+						
Gomel	Petrikov	Konkovichi	village	3 km east	2		+					+						
Gomel	Petrikov	Konkovichi	village	3.2 km east	1							+						
Gomel	Petrikov	Kopatkevichi	village		3					+			+			+		
Gomel	Petrikov	Ptich	village		7	+	+			+	+	+	+			+		
Gomel	Petrikov	Ptich	estuary of river	1							+							
Gomel	Petrikov	Slinki	village		1		+											
Gomel	Petrikov	Slinki	village	2 km southwest	1			+										
Gomel	Petrikov	Terebov	village		2						+					+		
Gomel	Petrikov	Tremlya	village		8	+	+			+	+	+	+			+		+
Gomel	Petrikov	Tremlya	river		1											+		
Gomel	Petrikov	Tremlya	fish-farm	3 km east	4					+	+		+			+		
Gomel	Petrikov	Tremlya	fish-farm	3 km northeast	3	+				+			+					
Gomel	Petrikov	Tremlya	fish-farm	4 km east	5	+				+		+	+			+		
Gomel	Rechitsa	Gagali	village	1 km east	2							+				+		
Gomel	Rechitsa	Gagali	village	1 km west	2							+				+		
Gomel	Rechitsa	Gagali	village	1 km northeast	2							+				+		
Gomel	Rechitsa	Gagali	village	1 km southeast	2							+				+		
Gomel	Rechitsa	Gagali	village	1 km southwest	2							+				+		
Gomel	Rechitsa	Gagali	village	1.6 km southwest	2							+				+		
Gomel	Rechitsa	Gagali	village	2 km south	3							+	+			+		
Gomel	Rechitsa	Gagali	village	2.4 km south	4	+						+	+			+		
Gomel	Rechitsa	Gagali	village	1.8 km south	2		+									+		
Gomel	Rechitsa	Gagali	village	1.9 km south	2							+				+		
Gomel	Rechitsa	Rechitsa	city		6	+	+				+	+	+			+		
Gomel	Rogatchyov	Vishin	village		2								+			+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Gomel	Rogatchyov	Vishin	village	2 km west	2							+				+		
Gomel	Svetlogorsk	Ola	river		3						+	+				+		
Gomel	Svetlogorsk	Parichi	urban village		1								+					
Gomel	Svetlogorsk	Parichi	urban village	1 km east	1											+		
Gomel	Svetlogorsk	Parichi	urban village	2 km east	2							+				+		
Gomel	Svetlogorsk	Parichi	urban village	3 km east	2							+				+		
Gomel	Svetlogorsk	Parichi	urban village	3 km south	2							+				+		
Gomel	Svetlogorsk	Stuzhki	village		1								+					
Gomel	Svetlogorsk	Stuzhki	village	2 km east	1							+						
Gomel	Svetlogorsk	Stuzhki	village	3 km east	1							+						
Gomel	Svetlogorsk	Stuzhki	village	3 km west	1							+						
Gomel	Svetlogorsk	Stuzhki	village	3 km south	2							+				+		
Gomel	Khoiniki	Babchin	village		6	+			+		+	+	+			+		
Gomel	Khoiniki	Babchin	village	2 km east	1	+												
Gomel	Khoiniki	Babchin	village	3 km south	4	+					+	+	+					
Gomel	Khoiniki	Dronki	village		5		+				+	+				+	+	
Gomel	Khoiniki	Dronki	village	1.5 km east	1	+												
Gomel	Khoiniki	Kozeluzhie	village		4		+		+		+	+						
Gomel	Khoiniki	Krasnopolie	village		1		+											
Gomel	Khoiniki	Krasnoselie	village		5	+				+	+		+			+		
Gomel	Khoiniki	Lomachi	village	2 km east	1	+												
Gomel	Khoiniki	Lomysh	village		4						+	+	+		+			
Gomel	Khoiniki	Masany	village		2		+					+						
Gomel	Khoiniki	Nebytov	village		1				+									
Gomel	Khoiniki	Novokuhnovshchina	village		2							+					+	
Gomel	Khoiniki	Orevichi	village		4		+				+	+	+					
Gomel	Khoiniki	Orevichi	village	1 km east	1	+												
Gomel	Khoiniki	Osov	village		1											+		
Gomel	Khoiniki	Pogonnoe	village		3						+	+	+					
Gomel	Khoiniki	Strelichevo	village		2				+							+		
Gomel	Khoiniki	Tulgovichi	village		1						+							
Gomel	Khoiniki	Khvoshchevka	village		2						+	+						
Gomel	Khoiniki	Khoiniki	city		8	+			+	+		+	+			+	+	+
Gomel	Khoiniki	Khoiniki	city	2 km north	1				+									

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Gomel	Khoiniki	Chemkov	village		2						+	+						
Grodno	Volkovysk	Novoselki	village		3	+	+			+								
Grodno	Volkovysk	Novoselki	village	1 km north	4		+					+	+			+		
Grodno	Volkovysk	Podros	village	1 km east	2		+									+		
Grodno	Volkovysk	Podros	village	3 km east	3							+	+			+		
Grodno	Voronovo	Radun	city	3 km west	3	+			+			+						
Grodno	Grodno	Bershty	village		1											+		
Grodno	Grodno	Gozha	village	5 km east	1					+								
Grodno	Grodno	Gozha-Krinichnyi	settlement	1 km east	1			+										
Grodno	Grodno	Kalety	village		3		+						+			+		
Grodno	Grodno	Kalety	village	3 km east	4		+					+	+			+		
Grodno	Grodno	Ozery	village		5		+		+			+				+		+
Grodno	Grodno	Ozery	village	lake Beloe	2				+							+		
Grodno	Grodno	Palenitsa	village	river Neman	1				+									
Grodno	Grodno	Palnitsa	village		2		+				+							
Grodno	Grodno	Palnitsa	village	1 km east	3					+		+				+		
Grodno	Grodno	Palnitsa	village	1 km west	2							+				+		
Grodno	Grodno	Palnitsa	village	1.3 km west	2							+				+		
Grodno	Grodno	Palnitsa	village	1.8 km west	2							+				+		
Grodno	Grodno	Polnitsa	village		1								+					
Grodno	Grodno	Porechje	village	2.4 km east	2							+	+					
Grodno	Grodno	Shabany	village	3 km east	2							+	+					
Grodno	Ivje	Gavya	river		1											+		
Grodno	Ivje	Malyi Chapun	village		7	+	+			+	+	+	+			+		
Grodno	Ivje	Malyi Chapun	village	2 km west	1		+											
Grodno	Ivje	Malyi Chapun	village	2 km lower by river	4						+	+	+			+		
Grodno	Ivje	Morino	village		1								+					
Grodno	Ivje	Morino	village	1 km east	1											+		
Minsk	Volozhin	Potashnya	village	river Berezina	4		+					+	+			+		
Grodno	Ivje	Pilyuzhino	village		1		+											
Grodno	Lida	Ditva	village		1		+											
Grodno	Lida	Ditva	village	0.4 km south	1					+								
Grodno	Lida	Lida-Grodno (Ì6)	highway	2.4 km east	2							+				+		
Grodno	Lida	Lida-Grodno (Ì6)	highway	2.4 km southeast	2							+				+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Grodno	Lida	Myto	village	1 km east	1							+						
Grodno	Lida	Myto	village	2 km east	1											+		
Grodno	Lida	Myto	village	2.4 km east	1											+		
Grodno	Lida	Myto	village	3 km east	2		+									+		
Grodno	Mostovsk	Zapolie	village		3		+					+	+					
Grodno	Mostovsk	Ros	estuary of river	1							+							
Grodno	Novogrudok	Lyubel	village		2		+				+							
Grodno	Novogrudok	Lyubets	village		2		+									+		
Grodno	Novogrudok	Lyubcha	village	1 km east	3							+	+			+		
Grodno	Novogrudok	Lyubcha	village	1 km north	3		+					+				+		
Grodno	Novogrudok	Lyubcha	village	2 km west	2							+				+		
Grodno	Novogrudok	Lyubcha	village	3 km west	1											+		
Grodno	Novogrudok	Ponemon	village		1								+					
Grodno	Novogrudok	Shchorsy	village		2		+						+					
Grodno	Oshmyany	Zhuprany	village	1 km east	1											+		
Grodno	Oshmyany	Zhuprany	village	2 km east	2		+									+		
Grodno	Shchuchin	Zachepichi	village		2							+	+					
Grodno	Shchuchin	Zachepichi	village	2 km west	1							+						
Grodno	Shchuchin	Zachepichi	village	2.4 km east	1							+						
Grodno	Shchuchin	Zachepichi	village	2.4 km southeast	1											+		
Grodno	Shchuchin	Zachepichi	village	3 km south	3							+	+			+		
Minsk	Berezino	Krasnyi Bereg	village		1											+		
Minsk	Berezino	Snuya	village		1											+		
Minsk	Berezino	Jakshitsy	village		1											+		
Minsk	Borisov	Bytcha	village		1											+		
Minsk	Borisov	Maloe Stakhovo	village		6		+				+	+	+			+	+	
Minsk	Borisov	Maloe Stakhovo	village	1 km west	2							+				+		
Minsk	Borisov	Maloe Stakhovo	village	1.4 km west	1							+						
Minsk	Borisov	Maloe Stakhovo	village	1.5 km north	3		+					+				+		
Minsk	Borisov	Maloe Stakhovo	village	1.6 km north	1								+					
Minsk	Borisov	Maloe Stakhovo	village	1.7 km east	3							+	+			+		
Minsk	Borisov	Maloe Stakhovo	village	1.8 km north	1							+						
Minsk	Borisov	Maloe Stakhovo	village	1.9 km east	2							+	+					
Minsk	Borisov	Maloe Stakhovo	village	2.5 km north	1							+						

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Minsk	Borisov	Palik	village		1											+		
Minsk	Borisov	Ukholody	village		1											+		
Minsk	Vileika	Boyary	village	3 km north	2		+									+		
Minsk	Vileika	Bojary	village	3 km north	4				+		+	+	+					
Minsk	Vileika	Bojary	village	5 km north	2		+									+		
Minsk	Vileika	Bojary	village	5 km north	5			+	+		+	+			+			
Minsk	Vileika	Budishche	village		4						+		+			+		+
Minsk	Vileika	Vileika	city		1											+		
Minsk	Vileika	Vileiskoe	reservoir		2		+									+		
Minsk	Vileika	Zalesie	village		5		+		+				+			+		+
Minsk	Vileika	Kobuzi	village	storage lake Vileiskoe	4						+					+	+	+
Minsk	Vileika	Matchitsy	village		1			+										
Minsk	Vileika	Matchitsy	village	storage lake Vileiskoe	1				+									
Minsk	Vileika	Sosenka	village		7		+	+	+			+	+			+		+
Minsk	Volozhin	Borovikovshchina	village	2 km west	2							+				+		
Minsk	Volozhin	Borovikovshchina	village	2 km northwest	2							+				+		
Minsk	Volozhin	Borovikovshchina	village	3 km west	1											+		
Minsk	Volozhin	Kaldyki	village		2							+				+		
Minsk	Volozhin	Kamenka	river		4		+					+				+		+
Minsk	Volozhin	Kamen	village		1		+											
Minsk	Volozhin	Kozliki	village		2							+				+		
Minsk	Volozhin	Kroman	lake	3 km north	2							+				+		
Minsk	Volozhin	Kutenyata	village	river Zapadnaya Berezina	5		+				+	+	+			+		
Minsk	Volozhin	Nerovy	village		3		+					+				+		
Minsk	Volozhin	Padnevichi	village	2 km of traps	1		+											
Minsk	Volozhin	Pervomaiskii	settlement		1						+							
Minsk	Volozhin	Pervomaiskii	settlement	2 km east	2							+				+		
Minsk	Volozhin	Pervomaiskii	settlement	river Isloch	2		+									+		
Minsk	Volozhin	Pershai	village		5		+			+		+	+			+		
Minsk	Volozhin	Pershai	village	3 km west	2							+				+		
Minsk	Volozhin	Peski	village	3 km south	1											+		
Minsk	Volozhin	Rakov	village		1						+							
Minsk	Volozhin	Rum	village		1		+											
Minsk	Volozhin	Sukhoj Borok	village	3 km west	2		+									+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Minsk	Volozhin	Ugly	village		1											+		
Minsk	Volozhin	Ugly	village	4 km west	4							+	+			+		+
Minsk	Volozhin	Ugly	village	5 km west	1								+					
Minsk	Volozhin	Ugly	village	river Volka	2												+	+
Minsk	Volozhin	Yatskovo	village		2							+				+		
Minsk	Volozhin	Yatskovo	village	3 km south	1											+		
Minsk	Dzerzhinsk	Aleksandrovo	village		1											+		
Minsk	Dzerzhinsk	Vasilevshchina	village		3		+	+	+									
Minsk	Dzerzhinsk	Negoreloe	urban village	2.5 km west	2							+				+		
Minsk	Dzerzhinsk	Rodina	village	river Zhest	3		+					+				+		
Minsk	Dzerzhinsk	Energetik	settlement		5		+		+			+				+		+
Minsk	Dzerzhinsk	Energetik	railway station	1 km northwest	1											+		
Minsk	Dzerzhinsk	Energetik	railway station	3 km west	1								+					
Minsk	Dzerzhinsk	Energetik	railway station	3.6 km west	2							+						+
Minsk	Dzerzhinsk	Energetik	railway station	4 km west	4							+	+			+		+
Minsk	Dzerzhinsk	Energetik	railway station	4.5 km west	1													+
Minsk	Krupki	Bobrik	river		4							+				+	+	+
Minsk	Logoisk	Zakolyuzhie	village		1				+									
Minsk	Logoisk	Krokva	village		4		+						+			+		+
Minsk	Logoisk	Selishche	village		1											+		
Minsk	Logoisk	Tsna	village		2		+		+									
Minsk	Logoisk	Chebotari	village		4		+		+			+				+		
Minsk	Logoisk	Chebotari	village	2 km west	2							+				+		
Minsk	Logoisk	Chebotari	village	3 km west	2							+				+		
Minsk	Minsk	Borovaja	village		1							+						
Minsk	Minsk	Volma	river		1											+		
Minsk	Minsk	Volchkovichi	village	storage lake Volchkovichskoe	1											+		
Minsk	Minsk	Volchkovichi	village	river Ptich	2										+	+		
Minsk	Minsk	Glebkovichi	village		1											+		
Minsk	Minsk	Dehan	village	3 km west	1							+						
Minsk	Minsk	Zelenoe	railway station		1							+						
Minsk	Minsk	Kolodishchi	settlement		10	+	+	+	+		+	+	+			+	+	+
Minsk	Minsk	Lipovaya Koloda	village		1											+		
Minsk	Minsk	Minsk	city		3				+			+				+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Minsk	Minsk	Minsk	city	Voloha street	1				+									
Minsk	Minsk	Minsk	city	Gintovta street	1				+									
Minsk	Minsk	Minsk	city	Kalinovskogo street	5	+			+				+			+		+
Minsk	Minsk	Minsk	city	Cosmonautov street	3	+			+							+		
Minsk	Minsk	Minsk	city	Kurchatova street	6	+					+	+	+			+		+
Minsk	Minsk	Minsk	city	Lobanka street	2				+			+						
Minsk	Minsk	Minsk	city	Suburban street	4						+			+		+		+
Minsk	Minsk	Minsk	city	Pritytskogo street	3				+			+						+
Minsk	Minsk	Minsk	city	Radial street	1				+									
Minsk	Minsk	Minsk	city	Uborevicha street	5	+			+			+	+		+			
Minsk	Minsk	Minsk	city	Central botanical garden	1											+		
Minsk	Minsk	Papernya	village	river Vyacha	1											+		
Minsk	Minsk	Podgai	village	river Ptich	1											+		
Minsk	Minsk	Priluki	village	river Ptich	1											+		
Minsk	Minsk	Ptich	railway station	river Ptich	1											+		
Minsk	Minsk	Selyuty	village		2		+											+
Minsk	Minsk	Selyuty	village	river Chernyavka	1											+		
Minsk	Minsk	Semkovo	village	river Chernyavka	1											+		
Minsk	Minsk	Staiki	village		1											+		
Minsk	Minsk	Strochitsa	village	storage lake Volchkovichskoe	2		+									+		
Minsk	Minsk	Shchomyslitsa	village		1				+									
Minsk	Mjadel	Naroch	lake		1											+		
Minsk	Nesvizh	Gorodeya	village	Alba fishery	4	+			+			+				+		
Minsk	Nesvizh	Nesvizh	city		1											+		
Minsk	Puhovichi	Dukora	village	2 km east	2							+	+					
Minsk	Puhovichi	Dukora	village	3.5 km east	1								+					
Minsk	Puhovichi	Dukora	village	4 km east	1				+									
Minsk	Puhovichi	Dukora	village	4.3 km east	1								+					
Minsk	Puhovichi	Sergeevichi	village	1 km west	1			+										
Minsk	Puhovichi	Talca	village	1 km southeast	3	+										+		+
Minsk	Puhovichi	Talca	village	3 km south	1							+						
Minsk	Puhovichi	Terebuty	village		3	+					+					+		
Minsk	Smolevichi	Airport Minsk-2	airport	1 km west	1											+		
Minsk	Smolevichi	Bykacheno	village		1											+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Minsk	Smolevichi	Volma	village		1											+		
Minsk	Smolevichi	Volma	village	2 km east	1			+										
Minsk	Smolevichi	Dehan	village		3	+						+				+		
Minsk	Smolevichi	Dubrovka	village		3		+					+				+		
Minsk	Smolevichi	Zasnitsa	village		1											+		
Minsk	Smolevichi	Lozovyj Kust	village		1		+											
Minsk	Smolevichi	Smolnitsa	village		3		+					+				+		
Minsk	Smolevichi	Shemetovo	village		2							+				+		
Minsk	Soligorsk	Soligorsk	city		1				+									
Minsk	Starodorogsky	Oressa	river		1											+		
Minsk	Starodorogsky	Oressa	river	2 km east.	1											+		
Minsk	Stolbtsy	Vysoky Bereg	tourist centre	1 km west	2							+				+		
Minsk	Stolbtsy	Zasulie	village		2			+										+
Minsk	Stolbtsy	Zasulie	village	2.6 km east	1							+						
Minsk	Stolbtsy	Zasulie	village	2.8 km east	1							+						
Minsk	Stolbtsy	Zasulie	village	3 km east	9	+	+		+		+	+	+			+	+	+
Minsk	Stolbtsy	Zasulie	village	3.4 km south	1			+										
Minsk	Stolbtsy	Zasulie	village	4 km south	1			+										
Minsk	Stolbtsy	Zasulie	village	5 km south	1			+										
Minsk	Stolbtsy	Karolina	village	5 km east	1											+		
Minsk	Stolbtsy	Kletishche	village	2 km east	2								+			+		
Minsk	Stolbtsy	Kletishche	village	3 km west	4							+	+			+		+
Minsk	Stolbtsy	Kolosovo	railway station	3 km west	1							+						
Minsk	Stolbtsy	Stolbtsy	city	2 km east	2							+	+					
Minsk	Uzda	Golovochi	village	3 km east	1											+		
Minsk	Uzda	Jezy	village		1											+		
Minsk	Uzda	Litvyany	village		3	+						+				+		
Minsk	Uzda	Podelniki	village		2		+									+		
Minsk	Cherven	Ivanichi	village		1											+		
Minsk	Cherven	Rudnja	village	river Usha	1				+									
Minsk	Cherven	Staryi Prud	village		1											+		
Minsk	Cherven	Staryi Prud	village		1											+		
Mogilev	Bobruisk	Bobruisk	city		2							+				+		
Mogilev	Bobruisk	Bobruisk	city	river Berezina	1								+					

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Mogilev	Bobruisk	Domanovo	village		2						+	+						
Mogilev	Bobruisk	Domanovo	village	2 km east	2							+				+		
Mogilev	Bobruisk	Pomenki	village	2 km east	2							+				+		
Mogilev	Bobruisk	Pomenki	village	2.2 km east	1							+						
Mogilev	Bobruisk	Pomenki	village	3 km south	1							+						
Mogilev	Bobruisk	Slobodka	village	3 km north	3							+					+	+
Mogilev	Byhov	Selets	village		2		+									+		
Mogilev	Byhov	Selets	village	3 km west	3		+					+				+		
Mogilev	Kostyukovichi	Kostyukovichi	city		1											+		
Mogilev	Mogilev	Bujnichi	village	4 km south	1											+		
Mogilev	Mogilev	Dashkovka	village		2							+				+		
Mogilev	Mogilev	Dashkovka	village	1 km west	3							+	+			+		
Mogilev	Mogilev	Dashkovka	village	3 km north	2							+				+		
Mogilev	Osipovichi	Verhi	village		3							+	+			+		
Mogilev	Osipovichi	Verhi	village	2 km south	1		+											
Mogilev	Osipovichi	Verhi	village	river Ptich	1		+											
Mogilev	Osipovichi	Priterpa	urban village		2						+	+						
Mogilev	Osipovichi	Priterpa	urban village	1.6 km east	1							+						
Mogilev	Osipovichi	Priterpa	urban village	2 km east	2							+				+		
Mogilev	Osipovichi	Priterpa	urban village	2 km northeast	2							+				+		
Mogilev	Osipovichi	Priterpa	urban village	2.7 km northeast	1							+						
Mogilev	Osipovichi	Slopishche	village		1		+											
Mogilev	Osipovichi	Slopishche	village	6 km south	1							+						
Mogilev	Osipovichi	Slopishche	village	river Ptich	1									+				
Mogilev	Osipovichi	Talka	village	1.6 km west	1							+						
Mogilev	Osipovichi	Shepichi	village		1											+		
Mogilev	Puhovichi	Talca	village	1.5 km east	2	+												+
Mogilev	Puhovichi	Talca	village	2 km east	1											+		
Mogilev	Puhovichi	Talca	village	3 km northeast	1			+										
Mogilev	Cherikov	Bakov	village		2						+	+						
Mogilev	Cherikov	Bakov	village	2 km east	4				+		+	+				+		
Mogilev	Cherikov	Bakov	village	2 km southwest	2							+				+		
Mogilev	Cherikov	Bakov	village	2 km south	6		+					+	+			+	+	+
Mogilev	Cherikov	Bakov	village	2.1 km southwest	2							+				+		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Mogilev	Cherikov	Bakov	village	2.3 km south	1							+						
Mogilev	Cherikov	Bakov	village	2.5 km south	1							+						
Mogilev	Cherikov	Bakov	village	2.7 km south	1							+						
Mogilev	Cherikov	Bakov	village	2.8 km east	1							+						
Mogilev	Cherikov	Bakov	village	3 km east	1											+		
Mogilev	Cherikov	Bakov	village	3 km west	3		+					+				+		
Mogilev	Cherikov	Bakov	village	river Soz	1				+									
Mogilev	Cherikov	Veprin	village	1 km south	2							+				+		
Mogilev	Cherikov	Rekta	river		2						+	+						
Mogilev	Cherikov	Cherikov	city		2						+	+						
Mogilev	Cherikov	Cherikov	city	1 km east	2							+				+		
Mogilev	Shklov	Kopys	village		1		+											
Mogilev	Shklov	Mezhnik	village		2		+		+									
Mogilev	Shklov	New Stajki	village	1 km south	1											+		
Mogilev	Shklov	Pleshchenitsy	urban village	1.5 km north	1							+						
Mogilev	Shklov	Pleshchinitsy	urban village	1 km north	1							+						
Mogilev	Shklov	Pleshchitsy	village		1											+		
Mogilev	Shklov	Pleshchitsy	village	1 km north	1											+		
Mogilev	Shklov	Pleshchitsy	village	2 km north	1											+		
Mogilev	Shklov	Pleshchitsy	village	3 km east	1											+		
Mogilev	Shklov	Pleshchitsy	village	3.5 km east	1								+					
Mogilev	Shklov	Pleshchitsy	village	4 km east	1											+		
Mogilev	Shklov	Podknyazhie	village		2		+		+									

REFERENCES

Afonin, V. Yu. 1999. [Succession processes in herpetocomplexes of Belorussia]. – In: Les, Nauka, Molodezh 2. Gomel: 8-9 (in Russian).

Afonin, V.Yu. 1999. [Mortality dynamics of the marrow cells in *Rana arvalis*]. – In: Strukturno-Funktsionalnoe Sostoyanie Biologicheskogo Raznoobraziya Zhivotnogo Mira Belarusi. Minsk: 151-152 (in Russian).

Afonin, V.Yu., Voitovich, A.M. and Novitsky, R.V. 2002. [Cytological and cytogenetic variability of brown frogs from various territories of Belarus. – In: Antropogennaya Dinamika Landshaftov i Problemy Sokhraneniya i Ustoichivogo Ispolzovaniya Biologicheskogo Raznoobraziya]. Minsk: 108-109 (in Russian).

Bannikov, A.G. and Belova, Z.V. 1956. [Materials on the study of amphibians and reptiles of Belovezhskaya Pushcha]. – Uchenye Zapiski Moskovskogo Gosudarstvennogo Pedagogicheskogo Instituta (61): 385-402 (in Russian).

Bannikov, A.G., Darevsky, I.S., Ishchenko, V.G., Rustamov, A.K. and Szczerbak, N.N. 1977. Opredelitel Zemnovodnykh i Presmykayushchikhsya Fauny SSSR [Guide to Amphibians and Reptiles of the USSR Fauna]. Moscow: Prosveshchenie, 414 p. (in Russian).

Berger, L. 1966. Biometrical studies on the population of green frogs from the environs of Poznan. – Ann. Zool. (Warszawa) 23 (11): 303-324.

Berger, L. 1968. Embryonic and larval development of F1 generation of green frog tadpoles. Zool. Polon. 18 (3): 381-390.

Borkin, L.J. 1984. The European–Far Eastern disjunctions in distribution of amphibians: a new analysis of the problem. – In: Ecology and Faunistics of Amphibians and Reptiles of the USSR and Adjacent Countries. Leningrad: 55-88 (in Russian).

Borkin, L.J. 2001. Speciation, hybridization and polyploidy in amphibians of Palearctics. – In: Problems of Hepretology. Puschino-Moscow: 46-48 (in Russian).

Borkin, L.J. and Pikulik, M.M. 1986. The occurrence of polymely and polydactyly in natural populations of anurans of the USSR. – Amphibia-Reptilia 7 (3): 205-216 (in Russian).

Borkin, L.J., Caune, I.A., Pikulik, M.M. and Sokolova, T.M. 1986. Distribution and structure of the green frog complex in the USSR. – In: Stidies in Herpetology. Prague: 675-678 (in Russian).

Borkin, L. J., Litvinchuk, S.N., Rosanov, J.M., Khalturin, M.D., Lada, G.A., Borissovsky, A. G., Faizulin, A.I., Kotserzhinskaya, I.M., Novitsky, R.V. and Ruchin, A.B. 2003. New

data on the distribution of two cryptic forms of the Common Spadefoot Toad (*Pelobates fuscus*) in Eastern Europe. – Russ. J. Herpetol. 10 (2): 111-118.

Caughley, G. 1977. Analysis of Vertebrate Populations. Ld. – N.Y. – Sydney – Toronto.

Dinesman, L.G. and Kaletskaya, M.L. 1952. [Methods of quantitative census of amphibians and reptiles]. – In: Metody Ucheta i Geograficheskoe Raspredelenie Nazemnoi Fauny. Moscow: 329-341 (in Russian).

Drobenkov, S.M. 1995. [Comparative analysis of feeding in sympatric snakes, *Vipera berus* (L.), *Natrix natrix* (L.) and *Coronella austriaca* (Laur.)]. – Ekologiya (Ekaterinburg) (3): 222-226 (in Russian).

Drobenkov, S.M. 1999. [Quantitative composition and number of amphibian and reptile associations in ecosystems of Belarus]. – In: Strukturno-Funktsionalnoe Sostoyanie Biologicheskogo Raznoobraziya Zhivotnogo Mira Belarusi. Minsk: 158-160 (in Russian).

Drobenkov, S.M. 2001. Influence of ecotones and patchy environment on species diversity and structure of herpetocomplexes of the forest zone of Europe. – In: Problems of Herpetology. Pushchino-Moscow: 86-89 (in Russian).

Elkin, Yu.A. and Ishchenko, V.G. 1979. [Experience of application of binary relations for estimation of morphological similarity (on the example of members of the genus *Rana*)]. – In: Zhurnal Obshchei Biologii 40 (4): 618-621 (in Russian).

Encyclopedic directory “Amphibians. Reptiles”. 1996.

Fedyushin, 1933. [Materials on the study of Mammalia, Aves, Reptilia and Amphibia in Belarus (results of zoological studies in the eastern part of Gomelskaya Province in summer 1929)]. – In: Mataryaly da Vyvuchennya Flery i Fauny Belarusi 7. Mensk: 3-42 (in Byelorussian).

Galaktionov, Yu.K., Efimov, V.M., Pikulik, M.M. and Kosova, L.V. 1995. [Ontogenetic mechanisms of morphometric adaptation in *Rana arvalis* (Anura,Ranidae) to physical and geographical environmental gradients]. – Vestnik Zoologii (1): 55-61 (in Russian).

Garanin, V.I. 1964. [On the role of amphibians in bird life]. – In: Prirodnye Resursy Volzhsko–Kamskogo Kraya (Zhivotnyi Mir). Moscow: 112-126 (in Russian).

Garanin, V.I. and Panchenko, I.M. 1987. [Methods of the study of amphibians in nature reserves]. – In: Amfibii i Reptilii Zapovednykh Territorii. Moscow: 8-25 (in Russian).

Geltman, V.S. 1982. Geograficheskii i Tipologicheskii Analiz Lesnoi Rastitelnosti Belorussii [Geographic & Typological Analysis of the Forest Vegetation of Belorussia]. Minsk: Nauka i Tekhnika, 326 p. (in Russian).

Giller, P.S. 1988. Community Structure and the Niche. Ld. – N.Y.: Chapman and Hill Publ.

Glaesner, L. 1925. Normentafeln zur Entwicklungsgeschichte des Gemeinen Wassermolches (*Molge vulgaris*). Jena, 49 S.

Guenther, R. 1990. Die Wasserfrosche Europas. Wittenberg-Lutherstadt: A.Ziemsen, 288 S.

Gumennyi, V.S. 2001. Peculiarities of anthropogenic influence on the batrachofauna of Grodno City and its surroundings. – In: Problems of Herpetology. Puschino-Moscow: 76-77 (in Russian).

Inozemtsev, A.A. 1969. [Trophic relationships of brown frogs in coniferous forests of Moskovskaya Province]. –Zoologicheskii Zhurnal 48 (11): 1687-1694 (in Russian).

Ishchenko, V. 1993. Life-span and growth in populations of the Common Frog, *Rana temporaria*. – In: Soc. Europaea Herpetol.: 7th Ordinary Gen. Meet. Barcelona: 81.

Ishchenko, V.G. 1978. Dinamicheskii Polimofizm Burykh Lyagushek Fauny SSSR [Dynamic Polymorphism of the Brown Frogs of USSR Fauna]. Moscow: Nauka Publ., 148 p. (in Russian).

Ishchenko, V.G. 1989. [Ecological mechanisms of population stability in amphibians]. – Ekologiya (Sverdlovsk) (2): 12- 19 (in Russian).

Ishchenko, V.G. and Ledentsov, A.V. 1987. [Influence of environmental conditions on dynamics of age structure in a population of *Rana arvalis*]. – In: Vliyanie Uslovii Sredy na Dinamiku Struktury i Chislennosti Populyatsii Zhivotnykh. Sverdlovsk: 40-51 (in Russian).

Ishchenko, V.G. and Ledentsov, A.V. 1993. Life-history traits in populations of the Moor Frog, *Rana arvalis* Nilss. – In: Soc. Europaea Herpetol.: 7th Ordinary Gen. Meet. Barcelona: 81.

Ishchenko, V.G. and Shchupak, E.L. 1979. [Inter-populational variability of growth and developmental rate in larval *Rana arvalis*]. – In: Populyatsionnye Mekhanizmy Dinamiki Chislennosti Zhivotnykh. Sverdlovsk: 49-60 (in Russian).

Ivanova, N.L. 1985. [Morphological peculiarities of youngs-of-the-year in some amphibian species grown in the conditions of different group densities]. – In: Ekologicheskie Aspekty Skorosti Rosta i Razvitiya Zhivotnykh. Sverdlovsk: 76-84 (in Russian).

Kashkarov, D. 1927. [Method of quantitative study of the fauna of vertebrates and of the analysis of obtained data]. – Trudy Sredneaziatskogo Gosudarstvennogo Universiteta ser. 8 (7) (in Russian).

Khandogii, A.V. 1995. Sostoyanie Fauny Amfibii Estestvennykh i Meliorirovannykh Poimennykh Zon Rek Belorussii [Condition of the Amphibian Fauna in Natural and Meliorated Zones of River Flood Plains in Byelorussia]. – Ph.D. Diss. Minsk: Inst. Zool. Acad. Sci. Belarus, 107 p. (in Russian).

Khandogii, A.V. 2001. Condition of population numbers of model species of amphibians estimated by the number of clutches in water bodies of Minsk. – In: Problems of Herpetology. Puschino-Moscow: 315-317 (in Russian).

Khandogii, A.V. 2001. Dynamics of habitat distribution and number of amphibians in Belarus in the course of agricultural use of drained lands. – In: Problems of Herpetology. Puschino-Moscow: 314-315 (in Russian).

Khmelevskaya, N.V. 1985. On the polymorphism of some elements of pattern in *Rana temporaria* of the Zvenigorod population. – In: Fenetika Populyatsii. Moscow: 171-173 (in Russian).

Kosova, L.V. 1996. Analiz Morfometricheskoi i Feneticheskoi Struktury Populyatsii Amfibii Roda Rana v Belorussii [Analysis of Morphometric and Phenetic Structure of Populations in Amphibians of the Genus Rana in Byelorussia]. – Ph.D. Diss. Minsk: Inst. Zool. Acad. Sci of Byelorussia, 99 p. (in Russian).

Kosova, L.V., Pikulik, M.M., Yefimov, V.M. and Galaktionov, Yu.K. 1992. Intraspecific variability of morphometric characters of Moor Frog Rana arvalis (Anura, Ranidae) of Byelorussia. – Zoologichesky Zhurnal 71 (4): 34-44 (in Russian).

Krapivny, A.A. and Kroshchenko M.I. 1954. [On the study of herpetofauna of the north of Byelorussia]. – In: Voprosy Gerpetologii. Leningrad: 35-36 (in Russian).

Kuzmin, S.L. 1992. Trofologiya Khvostatykh Zemnovodnykh: Ekologicheskie i Evolutsionnye Aspekty [Trophology of Tailed Amphibians: Ecological and Evolutionary Aspects]. Moscow: Nauka Publ., 168 p (in Russian).

Kuzmin, S.L. 1999. The Amphibians of the former Soviet Union. Sofia–Moscow: Pensoft Publ., 538 p.

Lada G.A., Borkin L.J. and Vinogradov, A.E. 1995. Distribution,population systems and reproductive behavior of green frogs (hybridogenetic *Rana esculenta* complex) in the Central Chernozem territory of Russia. – Russ. J. Herpetol. 2 (1): 46-57 (in Russian).

Lada, G.A. 1993. Ekologo-Faunisticheskii Analiz Amfibii Tsentralnogo Chernozemiya [Ecologo-Faunistic Analysis of Amphibians of Central Region]. Ph.D. Diss. St. Petersburg: Zool. Inst. Russ. Acad. Sci., 126 p. (in Russian).

Lada, G.A., Sokolov, A.S. 1999. Metody Issledovaniya Zemnovodnыh: Nauchno-Metodicheskoe Posobie [Methods of the Study of Amphibians: Scientific and Methodical Manual]. Tambov: Tambov State Univ Publ., 75 p (in Russian).

Lakin. 1980. Biometriya [Biometrics]. Moscow (in Russian).

Landscapes of Belorussia. 1989. Minsk (in Russian).

Lebedinsky, A.A. 1989. [Phenetic peculiarities of a population of *Rana temporaria* on urbanized territory. In: Nazemnye i Vodnye Ekosistemy]. Gorky: 66-72 (in Russian).

Lebedinsky, A.A., Golubeva, T.B. and Anisimov, V.I. 1989. [Polymorphism in brown and green frogs in the conditions of anthropogenic influence]. – In: Problems of Herpetology. Kiev 139-140 (in Russian).

Legler, J.M. and Sullivan, L.J. 1979. The application of stomach-flushing to lizards and anurans. – Herpetologica 35 (2): 144-158.

Liozner, L.D. 1975. [Newts *Triturus vulgaris*, *Tr. cristatus*]. – In: Obiekty Biologii Razvitiya. Moscow: 324-341 (in Russian).

Litvinchuk, S., Sokolova, T.M. and Borkin, L.J. 1994. Biochemical differentiation of the Crested Newt (*Triturus cristatus* group) in the territory of the former USSR. – Abh. und Ber. f. Naturkunde Magdeburg. 17: 67-74.

Litvinchuk, S.N. 1998. Sistematika i Rasprostranenie Tritonov Kompleksa Triturus cristatus (Salamandridae) v Rossii i Sopredelnykh Stranakh [Systematics and Distribution of Triturus cristatus complex in Russia and Adjacent Countries]. Ph.D. St. Petersburg: Zool. Inst. Russian Acad. Sci., 346 p (in Russian).

Litvinchuk, S.N., Rudyk, A.M. and Borkin, L.J. 1996. Observations on paedomorphic newts (*Triturus vulgaris*) from the former Soviet Union. – Russ. J. Herpetol. 2 (2): 39-48.

Martof B.S. 1953. Territoriality in the greeg frog, *Rana clamitans*. – Ecology 34: 165-174.

Nikolsky A.M. 1918. Faune de la Russie et des Pays Limitrophes: Amphibiens (Amphibia). Petrograd: Russ. Acad. Sci., 319 p. (English transl.: (1963): Fauna of Russia and Adjacent Countries: Amphibians. Jerusalem: Israel Progr. for Sci.).

Nikolsky, A.M. 1905 [1906]. Herpetologia Rossica. – Mem. Acad. Imp. Sci. de St. Petersbourg, Ser. Phys.-Math. 17 (1): 1-518 (in Russian).

Novitsky, R.V. 1996. Characteristics of polymorphism in the Common Frog (Rana temporaria) in Byelorussia - Advances in Amphibian Res. in the f. Soviet Union 1: 91-108

Novitsky, R. 2003a. Distribution and morphological variability of Bufonidae in Byelorussia. – In: Programme and Abstr. 12th Ord. Gen. Meeting Soc. Eur. Herpetol. St.Petersburg: 120.

Novitsky, R. 2003b. Size of prey in feeding spectrum of anurans. – In: Programme and Abstr. 12th Ord. Gen. Meeting Soc. Eur. Herpetol. St.Petersburg: 120-121.

Novitsky, R.V. 2005. [Estimation of the scale of amphibian mortality in the period of spring and autumn migrations on car roads in Byelorussia]. – In: Materiali Pershoi Konferentsii Ukrainskogo Gerpetologichnogo Tovaristva. Kiev: 122-124 (in Russian).

Novitsky, R.V., Bakharev, V.A., Andersen, A.M., Adrados, L.H. and Briggs, L.A. 2001. [Geographical variability of phenetic structure in *Bombina bombina* L. (Anura; Amphibia) in Denmark and Belarus]. – Vestsi Natsionalnoi Akademii Navuk Belarusi (2): 97-100 (in Russian).

Opatrny, E. 1980. Food sampling in live amphibians. – Vestn. Cs. Spolec. Zool. 44 (4): 268-271.

Orlov, B.N. and Gelashvili, D.B. 1985. Zootoksinologiya [Zootoxinology]. Moscow: Vysshaya Shkola Publ., 280 p. (in Russian).

Padutov, A.E. 1983. [Species composition and population number of green frogs on fishery ponds “Beloe” (Gomel Province)]. – In: Zhivotnyi Mir Belorusskogo Polesya, Okhrana i Ratsionalnoe Ispolzovanie. Gomel: 30-31 (in Russian).

Padutov, A.E., Teslyuk, L.A. and Padutov, E.E. 1981. [Distribution and number of amphibians on meliorative channels and on adjacent lands]. – In: Zhivotnyi Mir Belorusskogo Polesya: Okhrana i Ratsionalnoe Ispolzovanie. Gomel: 33-34 (in Russian).

Petrusenko, A.A. and Khmenko, V.N. 1989. [S.I.Medvedev’s method for the study of trophic relationships of vertebrates and prospects for its development]. – Vestnik Zoologii (1): 46-50 (in Russian).

Pianka E. 1981. Evolyutsionnaya Ekologiya [Evolutionary Ecology]. Moscow: Mir Publ., 400 p (in Russian).

Pikulik, M.M. 1976a. [Rate of growth and development of larvae of *Rana esculenta* and *R. arvalis* at their coexistence with larvae of R. temporaria]. – Doklady Akademii Nauk Belorusskoi SSR 20 (11): 1048-1050 (in Russian).

Pikulik, M.M. 1976b. [The effect of living conditions of amphibian larvae on their growth, development and genetic composition of generation of this year]. – Doklady Akademii Nauk SSSR 228 (3): 756-759 (in Russian).

Pikulik, M.M. 1977. Experimental study of growth and development of the larvae of *Rana temporaria* in natural conditions. – Ekologiya (Sverdlovsk) (3): 98-101 (in Russian).

Pikulik, M.M. 1978. Experimental study of variability of genetic composition in amphibian youngs-of-the-year. – In: Fiziologicheskaya i Populyatsionnaya Ekologiya Zhivotnykh (5\7): 85-89 (in Russian).

Pikulik, M.M. 1980. [Reproduction of *Rana temporaria* in Byelorussia]. – Vestsi Akademii Navuk Belaruskai SSR, Seryya Biyalagichnykh Navuk 106-111 (in Byelorussian).

Pikulik, M.M. 1982. [Influence of some ecological factors on dynamics of embryonic and larval development of *Rana temporaria*]. – Vestsi Akademii Navuk Belaruskai SSR, Seryya. Biyalagychnykh Navuk. (1): 93-98 (in Belorussian).

Pikulik, M.M. 1985. [Comparative characterization of the condition of herpetofauna of Berezinskii and Pripyatskii nature reserves]. – In: Zapovedniki Belorussii (10). Minsk: 133-140 (in Russian).

Pikulik, M.M. 1985. Zemnovodnye Belorussii [Amphibians of Byelorussia]. Minsk: Nauka i Tekhnika, 191 p (in Russian).

Pikulik, M.M. 1990. [Class Amphibia]. – In: Flora i Fauna Zapovednikov SSSR: Pozvonochnye Zhivotnye Berezinskogo Zapovednika. Moscow: 10-11 (in Russian).

Pikulik, M.M. 1991. Variability of herpetocomplexes and populations of dominant Amphibia and Reptilia species in natural and anthropogenic landscapes of Byelorussia. – In: Abstr. 6th Ord. Gen. Meet. Soc. Eur. Herpetol. Budapest: 71 (in Russian).

Pikulik, M.M. 1993. Izmenchivost Gerpetokompleksov i Populyatsii Dominiruyushchikh Vidov Amfibii i Reptilii v Estestvennykh i Antropogennykh Landshaftakh Belarusi [Variability of Herpetocomplexes and Populations of Dominant Species of Amphibians and Reptiles in Natural and Anthropogenic Landscapes of Belarus]. – D.Sci. Diss. St.Petersburg: Zool. Inst. Russ. Acad. Sci., 442 p. (in Russian).

Pikulik, M.M. 1995. Status and dynamics of amphibian populations in Belarus and the influence of anthropogenic factors on amphibians. – In: Amphibian Populations in the CIS: Current Status and Declines. Moscow: 21-25 (in Russian).

Pikulik, M.M. and Kosova, L.V. 1992. Morfometricheskaya i Feneticheskaya Diffrentsiatsiya Populyatsii Amfbii (na Primere *Rana arvalis*) [Morphometric and Phenetic Differentiation of Amphibian Populations (an Example of *Rana arvalis*) (Deposited manuscript, VINITI, 23.11.92, N 3325-V92). Moscow, 25 p (in Russian).

Pikulik, M.M. and Sidorovich, V.E. 1992. Evaluation of structure and functional relations of populations of semiaquatic predators and amphibians in the White Russia (Bielorussia). – Soviet J. Ecol. 22 (6): 365-371.

Pikulik, M.M. and Sidorovich, V.E. 1996. [Relationships between seasonal dynamics of amphibian distribution and reproductive peculiarities of *Lutra lutra*]. – Doklady Akademii Navuk Belarusi 40 (6): 80-83, 125 (in Russian).

Pikulik, M.M., Bakharev, V.A. and Kosov, S.V. 1988. Presmykayushchiesya Belorussii [Reptiles of Belarus]. Minsk: Nauka i Tekhnika Publ., 166 p. (in Russian).

Pikulik, M.M., Kosov, S.V., Drobenkov, S.M., Letetskii, A.A. and Khandogii, A.V. 1988. [Estimation of the influence of draining melioration of bogs on the condition of amphibians and reptiles (an example of Belorusskoe Polesie, upstreams of the Yaselda and the Nareva)]. – Vestsi Akademii Navuk BSSR, Ser. Biyal. Navuk (3): 117 (in Russian).

Pikulik, M.M., Kosov, S.V., Letetskii, A.A. and Khandogii, A.V. 1986. [Present state, problems of study and conservation of herpetofauna of nature reserves of Belarus]. – In: Problemy Okhrany Genofonda i Upravlenie Ekosistemami v Zapovednikakh Lesnoi Zony (2). Moscow: 175-177 (in Russian).

Pisarenko, S.S. and Voronin, A.A. 1976. Method of food study in live anurans. – Ekologiya (Sverdlovsk) (2): 106 (in Russian).

Puzachenko, 1983

Pyastolova, O.A. and Ivanova, N.L. 1979. [Influence of reproductive phenology on growth and developmental rates in *Rana arvalis* in the experiment]. – In: Populatsionnye Mekhanizmy Regulatsii Chislennosti Zhivotnykh. Sverdlovsk: 101-109 (in Russian).

Pyastolova, O.A., Ivanova, N.L. and Bugaeva, E.A. 1982. Influence of population density on the growth and development of *Rana arvalis* larvae in natural conditions. – Ekologiya (Sverdlovsk) (2): 75-79 (in Russian).

Rastitelnyi Pokrov Belorussii [Vegetation Cover of Belorussia]. 1969. Minsk (in Russian).

Rodionenko, O.G. 1962. [Species composition and feeding of amphibians and reptiles of Byelorussia]. – In: Vtoraya Biologicheskaya Konferentsiya BSSR: Tezisy Dokladov. Minsk: 88- 89 (in Russian).

Rodionenko, O.G. and Nedelin, K.T. 1979. [Ecological characterization of amphibians of Belorusskoe Poozerie]. – In: Novye Problemy Zoologicheskoi Nauki I Ikh Otrazhenie v Vuzovskom Prepodavanii 2. Stavropol: 329 (in Russian).

Ryzhevich, K.K. 1989. [Method of removing samples for estimation of number and density of amp[hibian populations]. – In: Vsesoyuznoe Soveshchanie po Probleme Kadastra i Ucheta Zhivotnogo Mira: Tezisy Dokladov (1). Ufa: 415-416 (in Russian).

Ryzhevich, K.K. 1989. [Quantitative characterization of hibernacula of *Rana temporaria* in water bodies of different types]. – In: Problems of Herpetology. Kiev: 217 (in Russian).

Sapozhenkov, Yu.F. 1961. [Materials to the study of amphibians and reptiles of Byelorussia]. – In: Fauna i Ekologiya Nazemnykh Pozvonochnykh Belorussii. Minsk: 185-194 (in Russian).

Schmalhausen, I.I. 1964. Proiskhozhdenie Nazemnykh Pozvonochnykh [The origin of Terrestrial Vertebrates]. Moscow: Nauka Publ., 272 p (in Russian).

Schwarz S.S. 1980. Evolyutsionnaya Ekologiya [Evolutionary Ecology]. Moscow: Nauka Publ (in Russian).

Shchupak, E.L. 1985. [Ecological aspects of growth and development of *Rana arvalis* larvae]. – In: Ekologicheskie Aspekty Skorosti Rosta i Razvitiya Zhivotnykh. Sverdlovsk: 22-36 (in Russian).

Shchupak, E.L. and Ischenko, V.G. 1981. [To the genetics of coloration polymorphism in *Rana arvalis* Nilss. 1. Light medio-dorsal stripe]. – In: Herpetological Investigations in Siberia and the Far East. Leningrad: 128-132 (in Russian).

Shklyar, A.Kh. 1973. Klimaticheskie Resursy Belorussii i Ikh ispolzovanie v Selskom Khozyaistve [Climatic Resouces of Belorussia and Their use in Agriculture]. Minsk: Vysheisha Shkola Publ., 432 p. (in Russian).

Shlyahtin, G.V. and Nosova, O.N. 1989. [Comparative analysis of ecological niches of coexisting amphibian species]. – In: Voprosy Ekologii i Okhrany Zhivotnykh v Povolzhie: Dinamika i Struktura Populyatsii. Saratov: 81-88 (in Russian).

Szczerbak, N.N. and Szczerban, M.I. 1980. Zemnovodnye i Presmykayushchiesya Ukrainskikh Karpat [Amphibians and Reptiles of Ukrainian Carpathians]. Kiev: Naukova Dumka Publ., 266 p. (in Russian).

Taraszczuk, S.V. 1984. [On the variability of *Rana arvalis* on the territory of Ukraine]. – Vestnik Zoologii (5): 80-82 (in Russian).

Terentjev, P.V. 1950. Lyagushka [The Frog]. Moscow: Sovetskaya Nauka Publ., 345 p (in Russian).

Terentjev, P.V. and Chernov, S.A. 1940. Opredelitel Zemnovodnykh i Presmykayushchikhsya SSSR [Guide to Amphibians and Reptiles of USSR]. Moscow–Leningrad, Uchpedgiz Publ., 340 p. (English transl.: 1965. Key to Amphibians and Reptiles of USSR. Jerusalem: Israel Progr. for Sci. Transl.).

Timofeev-Resovsky, N.V., Yablokov, A.V. and Glotov, N.V. 1973. Ocherk Ucheniya o Populyatsii [Account of the Population Doctrine]. Moscow: Nauka Publ., 228 p. (in Russian).

Tsaune, I.A. 1987. Sistematika i Rasprostranenie Gibridogennogo Kompleksa *Rana esculenta* na Territorii Latviiskoi SSR [Systematics and Distribution of Hybridogenic complex *Rana esculenta* in Latvia]. – Ph.D. Diss. Leningrad: Zool. Inst. USSR Acad. Sci., 180 p (in Russian).

Ushakov, V.A. and Beloborodova, I.Yu. 1989. [Influence of urbanization on population characteristics of *Rana temporaria*]. – In: Nazemnye i Vodnye Ekosistemy (12). Gorky: 60-66 (in Russian).

Ushakov, V.A. and Lebedinsky, A.A. 1984. [Features of some population characteristics in brown frogs in relation to their life on urbanized territory]. – In: Vid i Ego Produktivnost v Areale 5: Voprosy Gerpetologii. Sverdlovsk: 45-46 (in Russian).

Vershinin, V.L. [1987] 1988. Adaptive characteristics of *Rana arvalis* (Nilss.) groupings at the conditions of a big city. – Soviet J. Ecol. 18 (1): 39-43.

Voitovich, A.M. and Afonin, V.Yu. 1999. [Seasonal fluctuations of cell numbers with signs of apoptosis in the *Rana arvalis* marrow from different populations]. – In: Biologicheskie Ritmy. Brest: 64-65 (in Russian).

Voitovich, A.M., Eliseeva, K.G. and Afonin, V.Yu. 1999. [Occurrence of additional chromosomes in populations of *Rana arvalis* from the territory of Belorussia]. – In: Strukturno-Funktsionalnoe Sostoyanie Biologicheskogo Raznoobraziya Zhivotnogo Mira Belarusi. Minsk: 153- 164.

Vorontsova, M.A., Liozner, L.D., Markelova, I.V. and Pukhalskaya, E.Ch. 1952. Triton i Aksolotl [Newt and Axolotl]. Moscow: Sovetskaya Nauka Publ., 295 p. (in Russian).

Yablokov, A.V. 1987. Populyatsionnaya Biologiya [Population Biology]. Moscow: Vysshaya Shkola Publ., 303 p (in Russian).

Yanchurevich, O.V. 2001. Peculiarities of reproduction of amphibians in Grodno City and its surroundings. – In: Problems of Herpetology. Puschino-Moscow: 349-351 (in Russian).

Yurkevich, I.D., Golod, D.S., and Aderikho, V.S. 1979. Rastitelnost Belorussii, Ee Kartografirovanie, Okhrana i Ispolzovanie [Vegetation of Belorussia, Its Mapping, Conservation and Use]. Minsk: Nauka i Tekhnika Publ., 248 p. (in Russian).

Zhivotnyi Mir v Zone Avarii Chernobylskoi AES [Animal World in the Zone of the Chernobyl Disaster]. 1995. Minsk: Navuka i Tehnika Publ., 263 p. (in Russian).

Zhivotovsky, L.A. 1991. Populyatsionnaya Biometriya [Population Biometrics]. Moscow, 271 p. (in Russian).

This page intentionally left blank

Color Plates

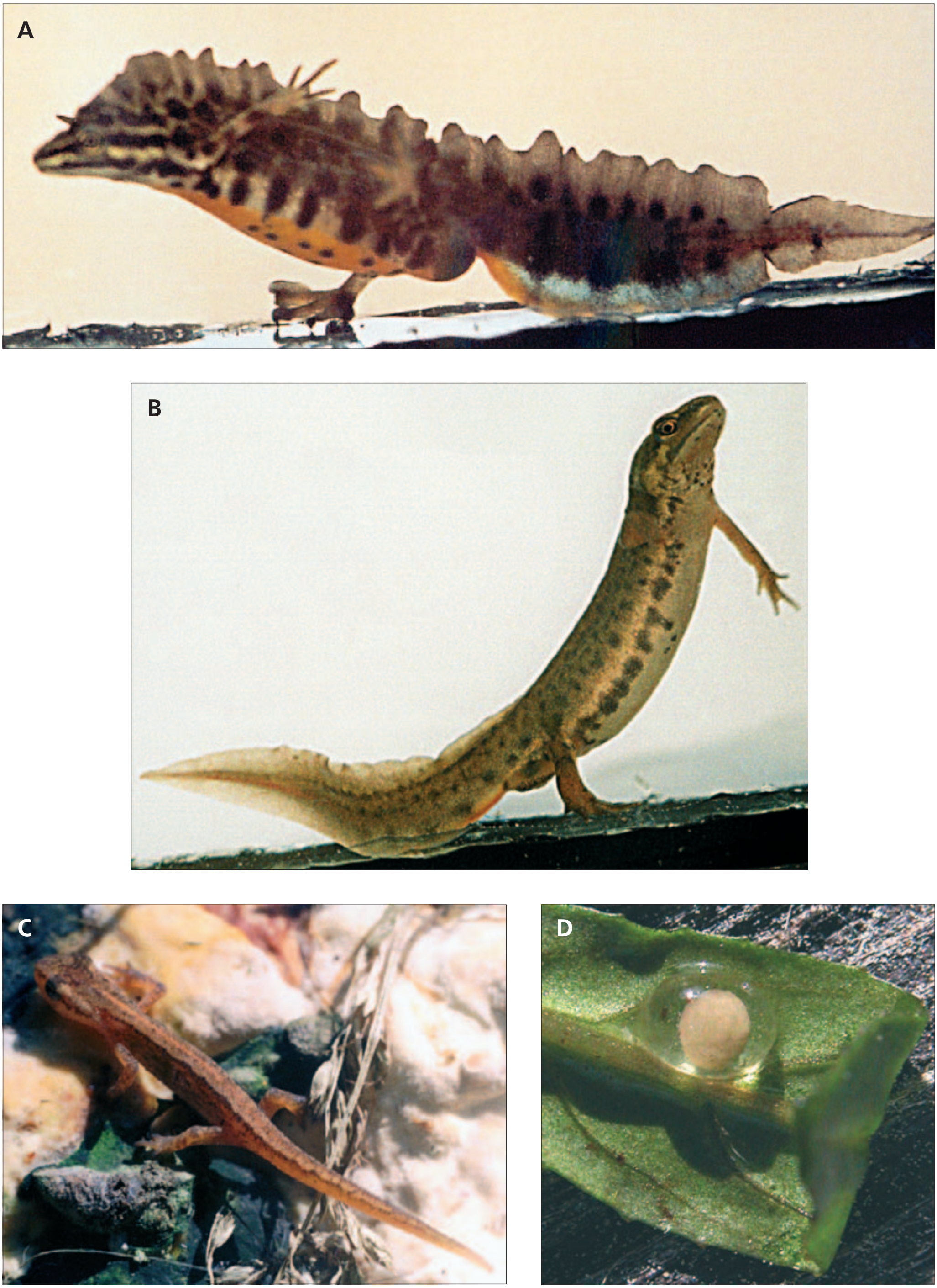
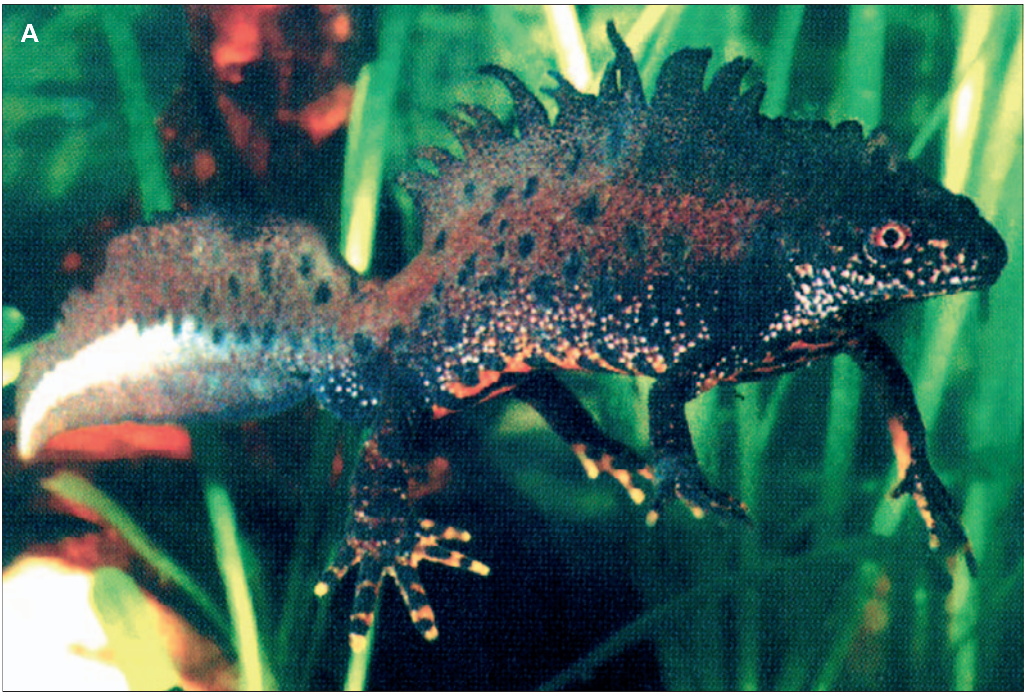


Plate 1. (A) Male, (B) Female, (C) young-of-the-year, and an (D) egg of the Smooth Newt, *Triturus vulgaris.*



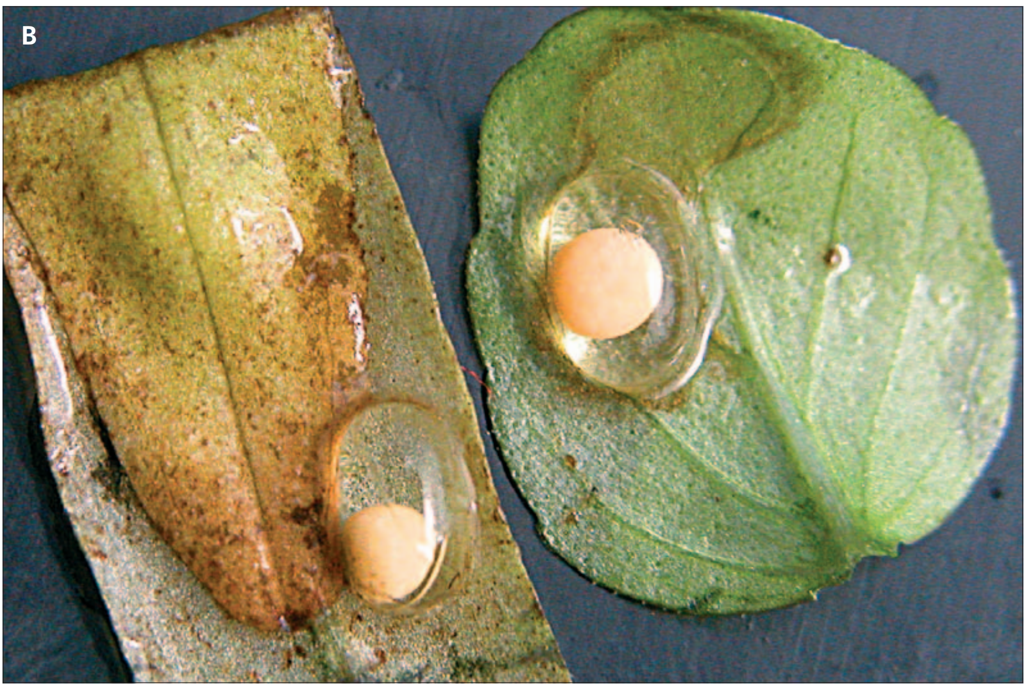


Plate 2. (A) Adult (from Russia: Kuzmin, 1999) and (B) eggs of the Great Crested Newt, *Triturus cristatus.*

Plate 3. Young Fire-Bellied Toad, *Bombina bombina.*

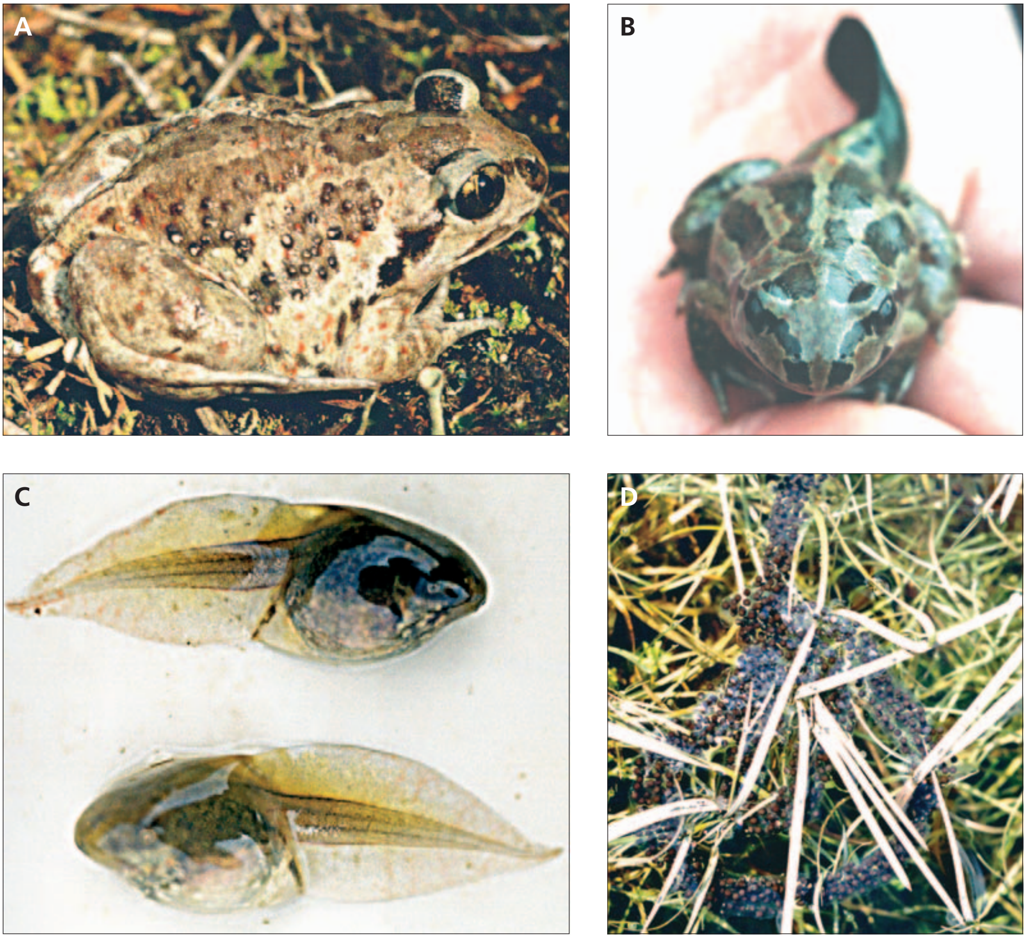


Plate 4. (A) Adult, (B) metamorphosing individual, (C) well-developed larvae, and a (D) clutch of the Common Spadefood, *Pelobates fuscus.*

Plate 5. Common Toad, *Bufo bufo:* (A) amplectant pair from Berezinskii Nature Reserve, an (B) adult with nuptial coloration; and a (C) dark adult.

Plate 6. Green Toad, *Bufo viridis.*

Plate 7. Natterjack Toad, *Bufo calamita* from (A) Sula, Stolbtsovkii District and from (B) Petrikovskii District.

Plate 8. Common Tree Frog, *Hyla arborea.*

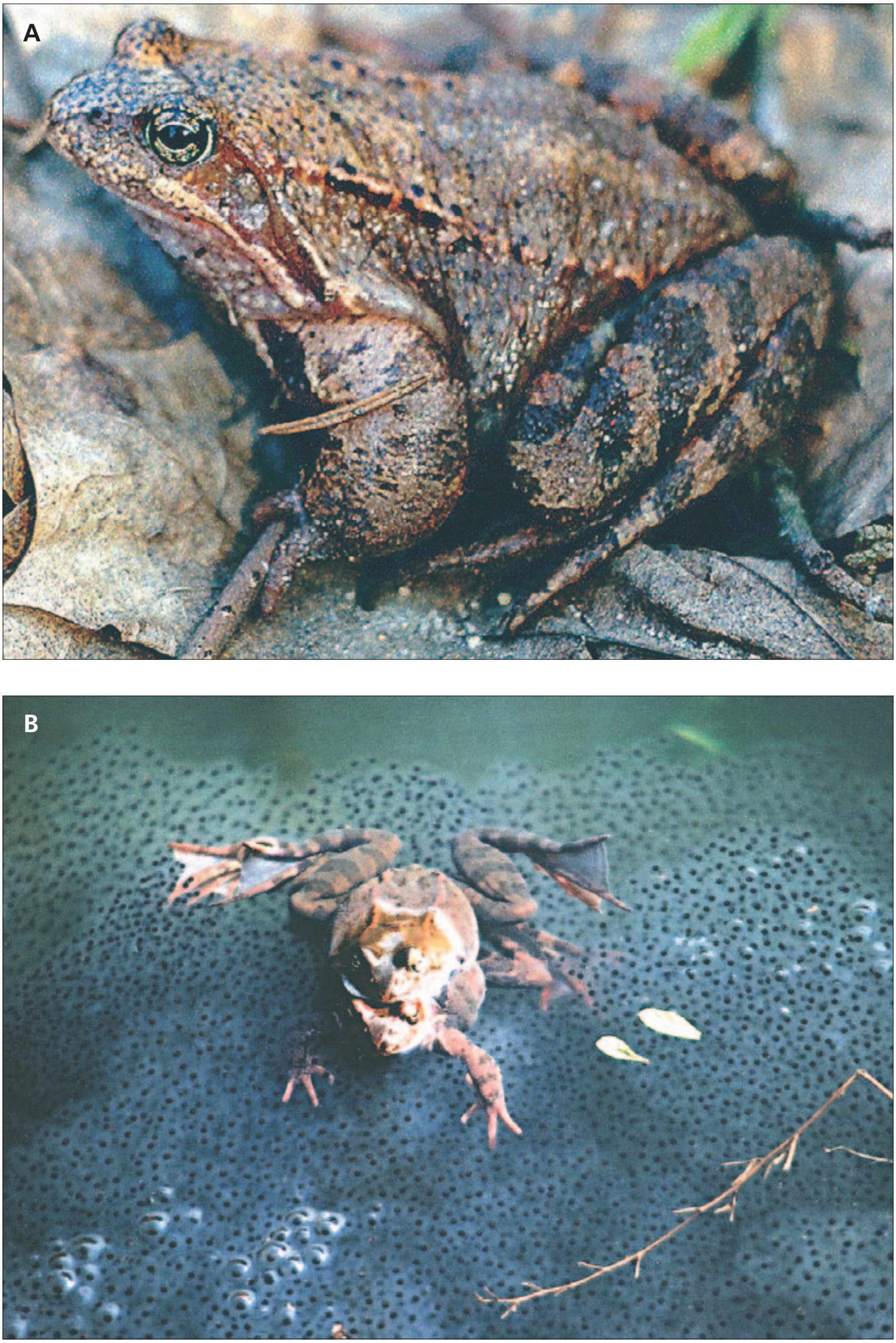


Plate 9. Common Frog, *Rana temporaria:* (A) adult; (B) pair on clutches from Berezinskii Nature Reserve.

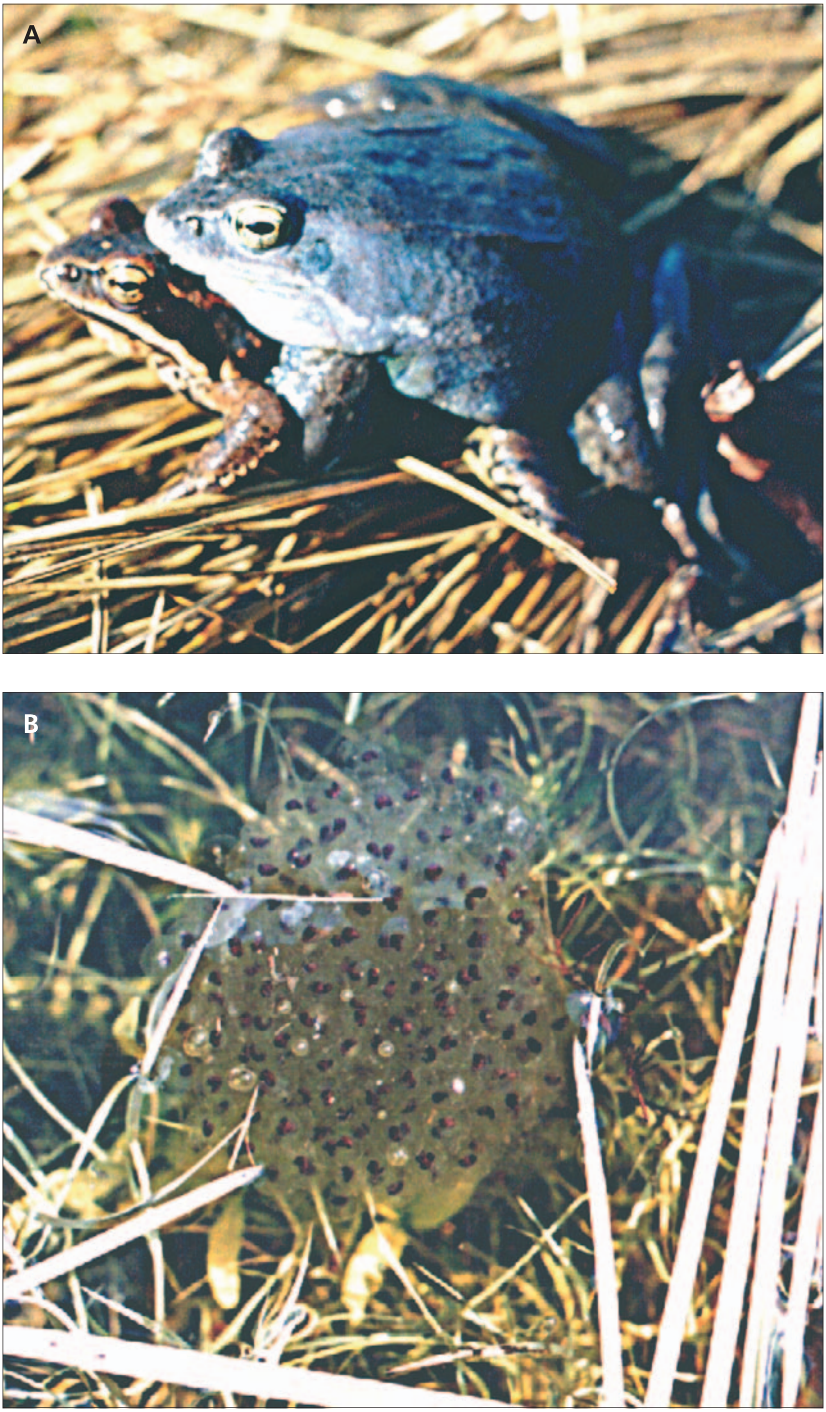


Plate 10. (A) Amplectant pair and a (B) clutch of the Moor Frog, *Rana arvalis.*

Plate 11. Marsh Frog, *Rana ridibunda* from Moskovskaya Province, Russia (Kuzmin, 1999).

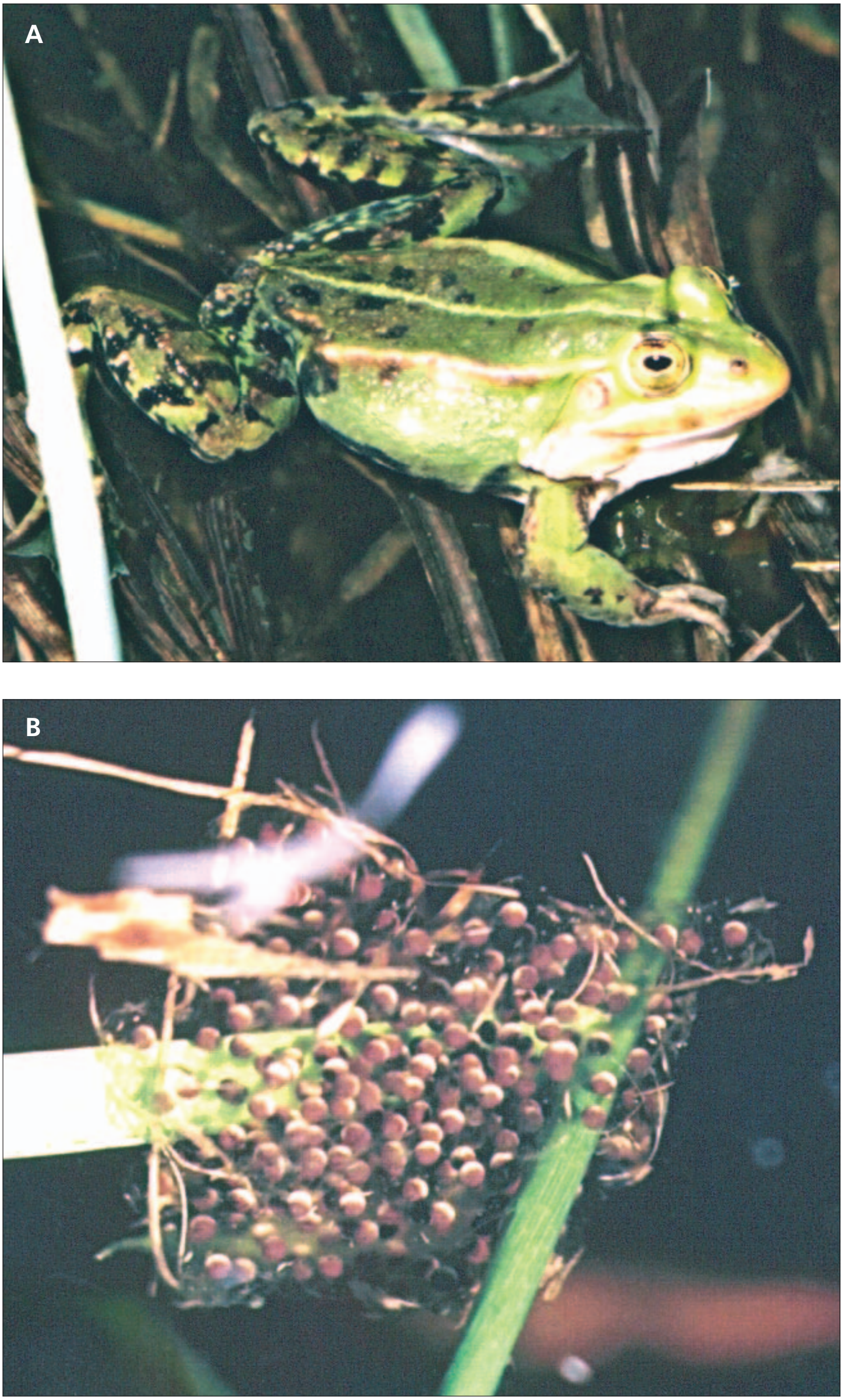


Plate 12. An (A) adult and (B) clutch of the Pool Frog, *Rana lessonae*.

Plate 13. Edible Frog, *Rana esculenta* from Glybokskii District.

Plate 14. Amphibian habitats: (A) breeding habitat of *B. bufo*, (B) *R. ridibunda* habitat at the Berezina River near Vitebsk City, (C) breeding habitat of *B. viridis*, (D) breeding habitat of *T. cristatus*, *B. bombina* and H. *arborea* at the delta of the Pripyat River, (E) amphibian breeding site at Gurby peat bogs, (F) habitat of *B.bombina*.

Plate 14. Continued.
(G) breeding habitat of *R. arvalis* and *R. temporaria* at the Berezina floodplain, (H) the delta of the Prypiat River with flooded oak tree, and (I) pastures along the Lan River.

INSTRUCTIONS FOR AUTHORS

"Advances in Amphibian Research in the Former Soviet Union" publishes papers in the monographic format, as well as thematic collections of papers.

Manuscripts written by authors from the former Soviet Union on all aspects of amphibian research, as well as papers of foreign authors concerning amphibian species from this territory, are accepted. Any topics of batrachology are accepted: systematics; distribution; ecology; behaviour; conservation; morphology; evolution; palaeontology; physiology; genetics; biochemistry; parasitology; keeping and breeding in captivity. The works may represent overviews; original studies; methods; and translations of classical treatises. Manuscripts should be sent to the Editor, Dr. Sergius L. Kuzmin, Institute of Ecology and Evolution, Russian Academy of Sciences, Leninsky Prospect, 33, Moscow 117071 Russia; phone (7095) 954-32-62; fax 954-55-34; e-mail <sevin@orc.ru> or <ipe51@yahoo.com>.

Manuscripts: should be in English, in the file format (see details below) and one hard copy.

Structure of the manuscript: name of author(s); address(es); abstract; contents; acknowledgments; main text; references; appendix; and figure captions.

Names: generic and specific names of organisms must always be given in italics, at the first (excluding Abstract) quotation in full, preferably with an indication of the author and year, afterwards in brief: e.g., *T. vulgaris*. Animal and geographic names should be capitalised: e.g., the Smooth Newt; the Caucasian Mountains; the Dnieper River. A separate sheet with geographic names in Russian is desirable.

References: should be in chronological order, e.g. (Thorn, 1968a, b; Golubev and Khozatsky, 1979; Pisachenko et al., 1981); without initials when noted directly, e.g. Bannikov (1958). All bibliographic data should be in the language of original, yet in Latin letters. If the Russian or other ex-Soviet original contains a parallel English, French, or German title of the book, collection, article, etc., that title should be given instead. For the journals translated completely (e.g., Russian J. Ecol.) bibliographic data of the translated version is preferable. The titles of books, journals, and collections (but not individual papers) should be capitalised; initials of the authors separated by commas; with an "and" in front of the name of the last author; publisher indicated only for books; the language indicated for materials published in national languages of the former USSR. Follow the examples:

Books: Ekvtimishvili, Z. 1948. Sakartvelos Ampibiebis Sarkvevi. Tbilisi: Tekhnika da Shroma Publ., 61 p. (in Georgian).

Thorn, R. 1968 a. Les Salamandres d'Europe, d'Asie et d'Afrique du Nord. Paris: ed. P. Lechevalier, 376 p.

Papers from collections: Golubev, N.S. and Khozatsky, L.I. 1979. Termotakticheskii optimum travyanoi lyagushki. – In: Gerpetologiya. Krasnodar: 36-43 (in Russian).

Lebedinsky, A.A. 1995. Status of amphibian populations in some parts of European Russia and the causes of their decline. – In: Amphibian Populations in the Commonwealth of Independent States: Current Status and Declines. Moscow: 54-58.

Pisachenko, A.I., Andreeva, A.P., Lobachev, V.M., and Lazarev, Yu. A. 1981. On differences in collagene properties of frogs of the genus *Rana*. – In: Herpetological Investigations in Siberia and the Far East. Leningrad: 78-82 (in Russian).

Journal papers: Bannikov, A.G. 1958. Die Biologie des Froschzahnmolches *Ranodon sibiricus* Kessler. – Zool. Jahrb. Syst.86 (3): 245-252.

Krasavtsev, B.A. 1938. K biologii krasnobryukhoi zherlyanki. – Priroda (Moscow) (5): 90-95 (in Russian).

Schmalhausen, I.I. 1955. The gills and gill-septa in Amphibia. – Zoologichesky Zhurnal 34 (2): 383-398 (in Russian).

Dissertations and their abstracts: *Cand. Sci. (=Ph. D.) Dissertation Abstract:* Vladimirova, I.G. 1974. Energetika Protsessa Regeneratsii na Raznykh Stadiyakh Ontogeneza Amfibii. – Ph.D. Diss. Abstr., Moscow: Institute of Developmental Biology, USSR Academy of Sciences, 24 p. (in Russian).

Doct.Sci. (=Dr. Sc.) Dissertation: Pisanets, E.M. 1995. Ropukhi Palearktiki (Minlivist, Sistematika ta Znachennya Poliploidii v Evolyutsii Rodu *Bufo*). – Dr. Sc. Diss., Kiev, Institue of Zoology, National Academy of Sciences of Ukraine, 299+260 p. (in Ukrainian).

Deposited manuscripts: Tarkhnishvili, D.N. 1989. Opredelitel Lichinok Khvostatykh Zemnovodnykh Fauny SSSR. Tbilisi: Tbilisi State Univ. (Deposited manuscript: GruzNIINTI 15 Nov.1989, no. 577-G89), 34 p. (in Russian).

Illustrations: should be attached to the maniscript in triplicate (1 original and 2 copies) on separate sheets; quoted as: Fig. 1. They should be of high quality and camera ready. After reduction they should be readable at the size 11.5 x 17.5 cm, so that all elements will be distinguishable, symbol and letter size will be not smaller than 1.5 mm. Graphs preferably submitted as computer files (see below).

Computerisation: the text (including tables) should be presented as *rtf or *doc files. Tables should be presented only as *rtf files. Illustrations should be in either *tif, *jpg, *bmp, *rtf or *stg formats. Resolution should be not less than 400 dpi.

Proofs and reprints: as a rule, proofs are not submitted to authors. Reprints are sent to authors by the publisher: Dr. Lyubomir D. Penev, Geo Milev Str. 13a, Sofia 1113 Bulgaria. E-mail: <pensoft@main.infotel.bg>.

Charge: publications (including colour pictures) are free of charge. No royalties are paid. Additional reprints may be purchased at a special rate.

Authors are fully responsible for their materials. The manuscripts may be returned to authors for revision. The Editorial Board has all rights to produce minor changes and reductions in the manuscript not changing the meaning of the publication.

Manuscripts not meeting these Instructions are not acceptable.

ПРАВИЛА ДЛЯ АВТОРОВ

В “Advances in Amphibian Research in the Former Soviet Union” публикуются монографии и тематические сборники статей.

К публикации принимаются рукописи авторов из бывшего Советского Союза по любым вопросам батрахологии, а также работы зарубежных авторов, выполненные на земноводных с территории бывшего СССР. Принимаются материалы по любым аспектам батрахологии: систематике, распространению, экологии, поведению, охране, морфологии, эволюции, палеонтологии, физиологии, генетике, биохимии, паразитологии, содержанию и разведению в неволе. Работы могут представлять обзоры, оригинальные исследования, описания методов, переводы классических трудов и т.д. Рукописи следует направлять редактору (Кузьмин Сергей Львович: 117071 Москва, Ленинский проспект, 33, Институт проблем экологии и эволюции РАН; тел. (7095) 954-32-62; факс 954-55-34; электронная почта <sevin@orc.ru> или <ipe51@yahoo.com>).

Рукопись: должна быть на английском языке, в электронной форме (см. ниже) с приложением 1 экз. распечатки (размер шрифта не менее 12 – как на обычной пишущей машинке, через 2 интервала, 25 – 30 строк на страницу).

Структура рукописи: заглавие; имя и первая буква отчества автора (например, Ivan I. Ivanov); адреса авторов; резюме на русском (с переводом названия публикации, инициалов и фамилий авторов) и английском языках; содержание на русском и английском языках; благодарности; основной текст на английском языке; список литературы; приложения; список иллюстраций; имя, отчество и фамилия автора с адресом и номерами телефона, факса и электронной почты.

Названия: родовые и видовые названия организмов при первом цитировании (не считая резюме) даются полностью, желательно с указанием автора и года описания, при следующих – в кратком виде: например, *T. vulgaris*. Английские названия организмов и географических объектов даются с большой буквы, например: the Smooth Newt; the Caucasian Mountains; the Dnieper River. Желателен список использованных названий (или кадастр) на русском языке.

Литература: ссылки в тексте даются в хронологическом порядке (Thorn, 1968a, b; Golubev and Khozatsky, 1979; Pisachenko et al., 1981); при прямом упоминании – без инициалов: Bannikov (1958). Все выходные данные пишутся на языке оригинала, но латинскими буквами, в скобках перевод. Если в оригинале имеется параллельный заголовок книги, сборника, статьи и т.д. на английском, немецком или французском языках, то следует приводить именно его, без скобок. Для переводимых журналов (например, “Экология”, “Доклады АН СССР” и др.) желательно приводить полные выходные данные английского варианта. Названия книг, журналов и сборников (но не статей) выделяются заглавными буквами; инициалы авторов – запятыми; перед фамилией последнего автора ставится “and”; название издательства – только для книг; для бывшего СССР указывается язык публикаций. В списке литературы указываются все авторы, а “et al.” не используется. Следуйте примерам:

Книги: Ekvtimishvili, Z. 1948. Sakartvelos Ampibiebis Sarkvevi [Guide to Amphibians of Georgia]. Tbilisi: Tekhnika da Shroma Publ., 61 p. (in Georgian).

Thorn, R. 1968 a. Les Salamandres d’Europe, d’Asie et d’Afrique du Nord. Paris: ed. P. Lechevalier, 376 p.

Статьи в сборнике: Lebedinsky, A.A. 1995. Status of amphibian populations in some parts of European Russia and the causes of their decline. – In: Amphibian Populations in the Commonwealth of Independent States: Current Status and Declines. Moscow: 54-58.

Pisachenko, A.I., Andreeva, A.P., Lobachev, V.M., and Lazarev, Yu. A. 1981. On differences in collagene properties of frogs of the genus *Rana*. – In: Herpetological Investigations in Siberia and the Far East. Leningrad: 78-82 (in Russian).

Golubev, N.S. and Khozatsky, L.I. 1979. Termotakticheskii optimum travyanoi lyagushki [The thermotactic optimum in *Rana temporaria*]. – In: Gerpetologiya. Krasnodar: 36-43 (in Russian).

Статьи в журнале: Schmalhausen, I.I. 1955. The gills and gill-septa in Amphibia. – Zoologichesky Zhurnal 34 (2): 383-398 (in Russian).

Bannikov, A.G. (1958): Die Biologie des Froschzahnmolches *Ranodon sibiricus* Kessler. – Zool. Jahrb. Syst. 86 (3): 245-252.

Krasavtsev, B.A. 1938. K biologii krasnobryukhoi zherlyanki [On the biology of *Bombina bombina*]. – Priroda (Moscow) (5): 90-95 (in Russian).

Диссертация и автореферат: *автореферат кандидатской диссертации:* Vladimirova, I.G. 1974. Energetika Protsessa Regeneratsii na Raznykh Stadiyakh Ontogeneza Amfibii. – Ph.D. Diss. Abstr., Moscow: Institute of Developmental Biology, USSR Academy of Sciences, 24 p. (in Russian).

докторская диссертация: Pisanets, E.M. Ropukhi Palearktiki (Minlivist, Sistematika ta Znachennya Poliploidii v Evolyutsii Rodu *Bufo*). – Dr. Sc. Diss., Kiev, Institue of Zoology, National Academy of Sciences of Ukraine, 299+260 p. (in Ukrainian).

Депонированная рукопись: Tarkhnishvili, D.N. 1989. Opredelitel Lichinok Khvostatykh Zemnovodnykh Fauny SSSR. Tbilisi: Tbilisi State Univ. (Deposited manuscript: GruzNIINTI 15 Nov.1989, no. 577-G89), 34 p. (in Russian).

Иллюстрации: прилагаются в 3 экз. (1 оригинал и 2 копии) отдельно от основного текста и цитируются так: Fig. 1. Они должны быть только высокого качества и полностью готовы к печати. После уменьшения они должны вписываться в формат 11,5 х 17,5 см так, чтобы все элементы были четко различимы и размер букв не был менее 1,5 мм. Рисунки с рукописными надписями не принимаются. Более желательна подача рисунков в электронной форме (см. ниже).

Электронная форма: текстовая часть рукописи (включая таблицы) должна быть в форматах *rtf или *doc. Таблицы принимаются только в формате *rtf. Иллюстрации должны быть в форматах *tif, *jpg, *bmp, *rtf или *stg. Разрешение рисунков – не менее 400 dpi.

Гранки и оттиски: гранки, как правило, не высылаются. Авторские экземпляры высылаются автору издателем (Dr. Lyubomir D. Penev, Geo Milev Str. 13a, Sofia 1113 Bulgaria. Электронная почта: <pensoft@main.infotel.bg>).

Плата: с авторов не взимается, в том числе за цветные иллюстрации; гонорар не выплачивается. Дополнительные оттиски могут быть приобретены у издателя за отдельную плату.

Авторы несут полную ответственность за свои материалы. Рукописи рецензируются. При необходимости рукописи возвращаются авторам на доработку. Редколлегия оставляет за собой право без согласования с автором вносить в рукописи незначительные изменения и сокращения, не меняющие смысла публикации.

Рукописи, не соответствующие настоящим Правилам, не принимаются.